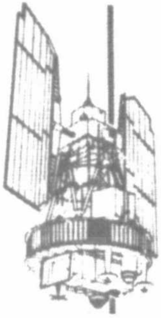

NASA CR-144522
ERIM 109600-33-F

(NASA-CR-144522) COLLATION OF EARTH RESOURCES DATA COLLECTED BY ERIM AIRBORNE SENSORS Final Report, Mar. - Jul. 1975 (Environmental Research Inst. of Michigan) 183 p HC $7.00 CSCL 05B G3/43

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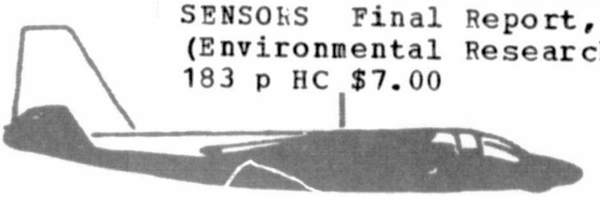
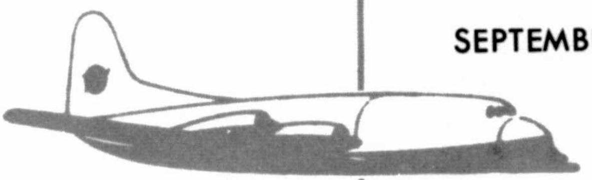


COLLATION OF EARTH RESOURCES DATA COLLECTED BY ERIM AIRBORNE SENSORS

PHILIP G. HASELL, Jr., et al.

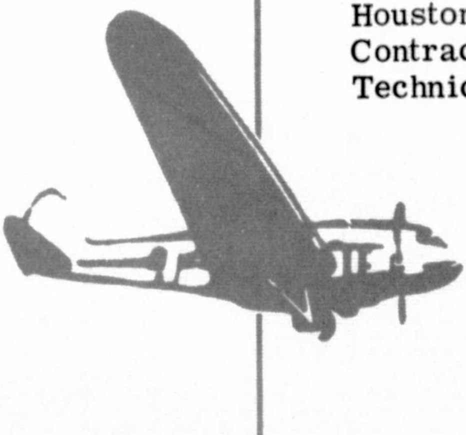
SEPTEMBER 1975



Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Lyndon B. Johnson Space Center
Houston, Texas 77058
Contract NAS 9-14123, Task XI
Technical Monitor: Dr. A.E. Potter



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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
109600-33-F		

4. Title and Subtitle	5. Report Date
COLLATION OF EARTH RESOURCES DATA COLLECTED BY ERIM AIRBORNE SENSORS	September 1975
	6. Performing Organization Code
7. Author(s) Philip G. Hasell, Jr., et al.	8. Performing Organization Report No. 109600-33-F
9. Performing Organization Name and Address Environmental Research Institute of Michigan Infrared and Optics Division P.O. Box 618 Ann Arbor, Michigan 48107	10. Work Unit No. Task XI 11. Contract or Grant No. NAS 9-14123
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Johnson Space Center Houston, Texas 77058	13. Type of Report and Period Covered Final Report March - July 1975 14. Sponsoring Agency Code

15. Supplementary Notes

Dr. A.E. Potter is Technical Monitor for this contract; Mr. Olav Smistad was Technical Monitor for Task XI.

16. Abstract

Earth resources imagery from nine years of data collection with developmental airborne sensors is cataloged for reference. The imaging sensors include single and multiband line scanners and side-looking radars. The operating wavelengths of the sensors include ultraviolet, visible and infrared band scanners and X- and L-band radar. Imagery from all bands (radar and scanner) were collected at some sites and many sites had repeated coverage. The multiband scanner data was radiometrically calibrated. Illustrations show how the data can be used in earth resource investigations. References are made to published reports which have made use of the data in completed investigations. Data collection sponsors are identified and a procedure described for gaining access to the data.

17. Key Words	18. Distribution Statement
Remote sensing, Multispectral scanner data, X-L band SLAR data, Airborne mapping, Earth resources applications	Initial distribution is listed at the end of the report

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	181	

PREFACE

The general objective of this task was to collate, for the convenience of other investigators, the earth resources data collected by ERIM's experimental airborne imaging sensors over the period from January 1966 through December 1974. Particular emphasis was placed on noting sites with repeated coverage over this period of time.

This task is one of eleven performed under a contract for continuing research into earth resources information systems which employ remote sensing of the environment from aircraft and satellites to gather data and which use automatic processing to extract information from the data. The broad objective of this multidisciplinary program is to develop information systems and practical tools which will provide planners and decision-makers with extensive, accurate information quickly and economically.

This report is submitted in fulfillment of NASA Contract NAS 9-14123, Task XI. The principal investigator for the task was Mr. Philip G. Hasell, Jr. of the Infrared and Optics Division of the Environmental Research Institute of Michigan (ERIM). The work was directed by Mr. Richard R. Legault, head of the IRO Division.

The principal investigator wishes to acknowledge the help of the following persons, who made significant contributions to the report: N. Roller, F. Thomson, T. Wagner and C. Wezernak, illustrations of applications; B. Haack, J. Ladd, D. Leu and C. Liskow, organization of flight information; S. Stewart, data retrieval discussion; and R. Featheringill, report compilation.

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LIST OF ABBREVIATIONS AND ACRONYMS

A/D	analog to digital conversion
aef	agricultural experimental farm
aes	agricultural experimental station
AFCRL	Air Force Cambridge Research Laboratory
AGL	above ground level
agri.	agricultural
Am. Electric Power	American Electric Power Service Corporation
Argonne	Argonne National Laboratory
Bu. Mines	United States Bureau of Mines
Bu. Reclamation	Bureau of Reclamation
BW	aerial camera black and white imagery
CDT	Central Daylight Time
cm	centimeter
co.	county
Col.	aerial camera color imagery
Col. IR	aerial camera false color imagery
Corp. of Eng.	U.S. Army Corps of Engineers
CRT	cathode ray tube
CST	Central Standard Time
db	decibels
dc	direct current
E. Tenn. State Univ.	East Tennessee State University
EDT	Eastern Daylight Time
ERIM	Environmental Research Institute of Michigan (formerly Willow Run Laboratories)
EST	Eastern Standard Time
FHA	Federal Highway Administration
FIR	far infrared scanner bands (8.0-14.0 μm)
Fla.	Florida
FM	frequency modulation
ft	foot
GHz	gigahertz (10^9 cycles per second)
GMT	Greenwich Mean Time
HATS	Houston area test site

in	inch
IR	infrared
IRIG	inter-range instrumentation group
kHz	kilohertz (10^3 cycles per second)
L-band	radar frequency of 1.165 GHz
LARS	Laboratory for Applications of Remote Sensing, Purdue University
LC	radar L-band with cross polarization
lk	lake
LP	radar L-band with parallel polarization
MDT	Mountain Daylight Time
Mich.	Michigan
MIR	middle infrared scanner band (3.0-6.0 μm)
mm	millimeter
MS	multispectral
MSS	multispectral scanner
MST	Mountain Standard Time
MSU	Michigan State University
mts.	mountains
multi	multiple
n/a	not available
NASA	National Aeronautics and Space Administration
NASA/GSFC	NASA, Goddard Space Flight Center
NASA/JSC	NASA, Lyndon B. Johnson Space Center
NASA/KSC	NASA, John F. Kennedy Space Center
NASA/Lewis	NASA, Lewis Research Center
NASA/Wallops	NASA, Wallops Station
Natl. Park Serv.	National Park Service
N. C.	North Carolina
NE$\Delta\rho$	noise equivalent change in reflectance
NEΔT	noise equivalent change in temperature
NIR	near infrared scanner band (0.7-3.0 μm)
North Amer. Rock.	North American Rockwell
NOAA	National Oceanographic and Atmospheric Administration
NPWRC	Northern Prairie Wildlife Research Center
nw	northwest
Oregon State U.	Oregon State University

PDT	Pacific Daylight Time
PI	principal investigator
PST	Pacific Standard Time
Purdue Univ.	Purdue University
r	river
RF	radio frequency
se	southeast
sec.	second
SLAR	side looking airborne radar
so.	south
S. Dakota State U.	South Dakota State University
sta.	station
State Hwy. Adm.	State Highway Administration
sw	southwest
twp.	township
TVA	Tennessee Valley Authority
U.	university
U. of Calif.	University of California
U. of Kansas	University of Kansas
U. of M	University of Michigan
UP	upper peninsula (of Michigan)
USDA	United States Department of Agriculture
USDI	United States Department of Interior
USGS	United States Geological Survey
UV	ultraviolet scanner bands (0.30-0.40 μm)
VIS	visible wavelength scanner bands (0.40-0.70 μm)
w	west
WR	Willow Run Airport
WRL	Willow Run Laboratories (now ERIM)
X-band	radar frequency of 9.3 GHz
XC	radar X-band with cross polarization
XP	radar X-band with parallel polarization

COLLATION OF EARTH RESOURCES DATA COLLECTED BY ERIM AIRBORNE SENSORS

1 INTRODUCTION

This report was prepared under the direction of NASA/JSC to provide investigators with a convenient reference to the earth resources imagery collected by ERIM airborne sensors during the period January 1966 through December 1974. The imagery was originally collected for a specific investigator, for a specific study, at a specific time. However, the cumulative effect of this random sampling of the earth's surface is to produce historical coverage of some sites, with multi-sensor coverage in some cases, with the potential for examining changes in sites over relatively long time periods by comparing current data with the stored data. This collation includes data collected by ERIM's thermal and multispectral optical scanners and its X- and L-band imaging radar system.

1.1 BACKGROUND

NASA has supported ERIM to some degree in its development of remote sensing techniques since the mid-1960's and to a significant extent since 1969. In 1974 NASA support of data collection using ERIM's passive optical scanners and active radar imaging systems was terminated due to budget cutbacks and the availability of this type of data from their own and commercial instrumentation. With their interest in supplying earth resource investigators with potentially useful data at minimum cost, however, it is appropriate that NASA should fund this effort to collate and publicize the large amount of earth resources data available at ERIM. During the past five years, about 75% of ERIM's airborne data collection has been supported by NASA and 95% of the data have been collected at Government expense. Thus, most of the data belong to United States taxpayers, constituting a national asset that should be used to advantage in establishing remote sensing applications.

All of the optical scanner imagery is stored at ERIM on analog magnetic tapes in an electrical format easily retrievable for machine processing or reformatting on tape or film. The signals reproduced from the tapes can be inserted directly into ERIM analog and digital computers and the tape-to-film imagery transfer equipment. Processing of the raw data at ERIM is available as part of the data retrieval function.

The radar data are recorded inflight on film in a holographic form. This original recording must be optically processed to produce imagery which can then be recorded in analog form on film, or in digital form on magnetic tape. The inflight film recording and, in most instances, processed imagery on film are stored at ERIM for reference.

1.2 SIGNIFICANCE OF HISTORICAL DATA SETS

ERIM's nine-year collection of earth resources imagery using airborne sensors constitutes a major investment which can be exploited to answer a number of important design questions for future sensors. The operations over many different environmental situations insures that many applications-oriented sensor configuration questions can be addressed. The variety of scenes mapped, and in many cases the repetitive nature of the data over these regions, will allow temporal and seasonal variables to be assessed.

Many important questions must still be fully answered before a successful operational sensor system is evolved for monitoring those activities of a dynamic nature encountered in vegetative and water resource applications. The varied spectral bands registered over this nine-year period offer an opportunity to evaluate the improvement in classification accuracies from changes in bandwidths and band locations, using data from the real world.

The imagery already collected is a time snapshot-sample of the environment, both in its seasonal cycle and in the status of environmental quality at the time of monitoring. This capturing over time of the electromagnetic signature of the earth's surface allows a number of important questions and measurements to be answered or derived. Even more dramatically, the data base allows recently developed processing techniques and procedures to be applied to the early data years after they were collected, so that actual environmental data can be extracted from them.

An example of this involves water quality applications. Only recently has it been feasible to measure chlorophyll a concentrations in lakes and coastal areas using a combination of spectral channels in a computer program. The data bank has a number of repetitive looks at the coastal areas of eastern Lake Michigan and the Detroit River. Both areas have received much attention by the EPA, the State of Michigan, and the Great Lakes Basin Commission. A number of industrial outfalls, power generating sites, and river discharges occur in the areas already mapped. It is now possible to trace changes in environmental quality (improvement and/or degradation) in these areas, thus establishing a new and valuable dimension in remote sensing of the environment. Also, the technical specification information on the best wavelengths, resolution, season, swath width, time between monitoring missions, and the like can be ascertained.

A similar situation arises with measures of changes in land use, growth of urban areas, population projections and degradation of the environment due to large projects like highways, power generating sites and utility line corridors.

A historical record of surface imagery allows changes in residential and commercial areas at the expense of agricultural and forested lands to be monitored, thus allowing policies, plans, and predictions of planners and administrators to be followed, models checked and valuable lessons learned.

In the crop inventorying applications, coverage over the last nine years allows a verification of yield predictions versus actual production reports. In many cases, verifying statistical data is reported a year or so after a season was monitored, so that processing of the early data can then be more easily evaluated. Only in the last year has some progress been made in crop-yield modeling and prediction; now forecasts made on a sampled basis can be evaluated, using the already collected data at a considerable saving in costs.

A historical data set provides a ready-made experimental basis for checking new applications-oriented questions. Its value will also increase as time passes and further changes in the environment occur. An organized data set will also serve future potential investigators both for training and verification purposes.

In collating the data, ERIM has presented examples of imagery illustrating the capability of airborne remote sensing and data processing. Examples were chosen from some of the major scientific disciplines. In addition to illustrations of what has been done with the data sets, some of the things that could be done are discussed. Emphasis is placed on illustrations which note scene changes with time or which provide complementary scene descriptions from optical and radar imagery.

Some 40,000 flight line miles (74,000 km) of data are stored in retrievable form. The bulk (36,000 miles) of this data is calibrated multispectral scanner (MSS) imagery collected over sites in the continental United States during a nine-year period. Another 1000 miles of thermal scanner imagery were collected over sites in the continental United States, Puerto Rico and Iceland during a three-year period. The remaining 3000 flight line miles of data are side-looking airborne radar (SLAR) imagery of continental United States sites over a six-year period. The spatial resolution of the imagery varies from 1 to 30 meters with a predominant resolution of 3 to 10 meters. Swath widths for a single pass vary from 0.6 to 6 km.

Over one hundred sites have repeated MSS coverage; some have repetitive coverage by time of day, month, year and decade. Eight sites have both MSS and SLAR coverage. The MSS coverage is at ultraviolet, visible, and infrared wavelengths between 0.32 and 14.0 μm. The SLAR coverage is at X- and L-band frequencies with dual polarization received in each band.

2
MULTISPECTRAL REMOTE SENSING: A NEW TOOL FOR RESOURCE MANAGERS

2.1 THE REMOTE SENSING CONCEPT

Remote sensing is a means of obtaining information about portions of the biosphere by noncontact methods. This information is derived from an analysis of patterns of radiation reflected or emitted from objects in different and discrete regions of the electromagnetic spectrum. The use of aircraft or satellites to collect remote sensing data provides a capability for synoptic looks at environments that makes it possible to deal more effectively with large or complex ecosystems. In this way, remote sensing forms a bridge between intensive problem-solving oriented research on small study sites and the application of the resource management techniques thus developed to larger units, such as counties, watersheds, or whole states.

Remote sensing began at ERIM in the early 1960's as an offshoot of military and space research into new surveillance and reconnaissance techniques. First efforts in multispectral sensing were focused on the use of multiple-lens cameras which produced several images of a scene in different wavelength regions by taking simultaneous photos using different film-filter combinations. When it came time to analyze this data, however, it rapidly became obvious that, except for simple cases where only a few things were being compared over a limited area, the load placed on the photo-interpreter by the additional detail this technique provided was overwhelming. The rapid input, output and analysis rates of computers appeared to be one way to cope with this enormous data-interpretation task and the problems of timeliness associated with it. As a result, emphasis in the developing remote-sensing technical community shifted to developing the technology necessary to record radiation signals from the environment in multiple electronic channels on magnetic tape in order to make them computer compatible.

At this point, in the mid-1960's, NASA became interested in supporting this emerging technology and initiated the first of its continuing programs which have funded remote-sensing investigations aimed at improving earth resources management. From the beginning ERIM's aircraft and sensor systems have been a major part of the data collection team used by NASA to support these investigations. Simultaneously, a parallel program, designed to provide investigators with a full spectrum of the necessary data processing and analysis techniques needed to accomplish their objectives, was also developed at ERIM.

Since that time ERIM's joint effort in the field of data collection and data analysis have developed into a cohesive and focused program. During its existence it has passed through roughly three phases which accurately reflect the continuing development of the multispectral remote sensing concept and its application to the problem of earth resources management. These three phases and what they accomplished are discussed in the next section.

2.2 ERIM AIRBORNE SENSOR PROGRAM

The ERIM airborne sensor program started in 1966 with modified military infrared scanners mounted in a C-47 aircraft. Over the next nine years the ability to routinely collect high quality, investigator-specified multispectral data was achieved through modification of equipment, standardization of data collection procedures, and streamlining of the instrumentation operation which permitted a reduction of the sensor system crew from five to two. The scanner system was improved by constructing a single scanner (M7) for all wavelengths from ultraviolet to thermal infrared, thus making possible the collection of full spectrum, truly multispectral data. At the same time, the system's electronics and tape recording system were improved. All these developments helped improve reliability and data quality so that the objective of the Phase I program - to prove the feasibility of collecting remote sensing data with airborne multispectral scanners - was realized.

The Phase II program consisted of collecting and analyzing data to demonstrate the utility of multispectral scanner data when applied to various resource management problems. Through a program of data collection and analysis funded by NASA, the utility of these data were demonstrated in agriculture, geology, water quality, wildlife management, forestry, and other natural resources management areas. Later in this report, case studies are presented which cite specific resources management problems in these areas and show the contribution made to resources management by a variety of processed multispectral data. The joint data collection and processing aspects of this phase, which reached their peak in 1969-1972, demonstrated that there was indeed promise in the use of properly processed multispectral scanner data in a variety of resource management areas, and also helped justify the launch of the first Earth Resources Technology Satellite [ERTS (now LANDSAT)], on 23 July 1972.

Phase III, the refinement of processing techniques and the joint use of multispectral data from satellite and aircraft platforms continues today. While much of the data collection capability has now been taken over by NASA, the ERIM airborne sensors did collect a number of data sets in support of ERTS and SKYLAB investigations. While it is intuitively obvious that an optimum mix of sensor data for most applications will be some satellite and some aircraft data, the actual working nature of this mix has not been precisely defined. Because of this probable eventual need for aircraft sensor data to help solve resources management problems operationally, there continues to be a requirement for an aircraft sensor capability. One objective of this catalog is to familiarize potential users with the results obtained from one source of this type of data.

The development of radar remote sensing techniques at ERIM has paralleled that of the MSS but has not progressed as far in terms of specific earth resources applications. The ERIM

X-band Side-Looking Airborne Radar (SLAR) system, developed for military reconnaissance investigations, was first used in earth resources applications in 1968. An L-band capability was added in 1971, but the system has been used infrequently for earth resources data collection. Classification processing techniques can be used with the multiband radar data; however, the utility of the radar data for this type of processing is currently limited by a lack of quantitative measure and stability from scene to scene. System design modifications have been proposed to overcome these constraints. Presently, the main advantage of radar remote sensing are its ability to see through clouds, its range-independent spatial resolution, and its large swath width at relatively low altitudes.

2.3 SUPPORTING DATA PROCESSING TECHNIQUES

A variety of data processing techniques were developed,in response to the needs of investigators interested in natural resource management, to extract various types of information from multispectral data. At the outset of the program, the basic need was for a capability for computer processing of the multispectral data, in order to help the human interpreter cope with the analysis load imposed by up to 12 simultaneously collected bands of spectral data. The case studies presented later in this chapter illustrate the progress eventually made toward this goal. In this section, the actual nature of several of the specific data processing techniques that were developed and which are now in common use are briefly described to provide the reader with a better understanding of the rationale which underlies their use in the cited examples. It is not the intention of this section to set forth in depth the limitations and implementation of these techniques. Readers interested in more detail in this regard are referred to Appendix A.

The techniques that have been found useful are (color-coded) single-channel calibrated signal-level slicing, creation of false color films, ratioing and multispectral signature recognition (or pattern recognition).

2.3.1 SINGLE-CHANNEL CALIBRATED LEVEL SLICING

For certain applications, single-channel calibrated level slicing is adequate to extract the desired information from electronically recorded data. The major difference between this technique and the density slicing techniques used on photography is that the slicing levels can be calibrated more precisely. This can be done through the use of calibration sources in the in the sensor itself (e.g., temperature calibration plates), and is successful because the dynamic range of remote sensing data is recorded linearly and more predictably on tape than on film.

Level-sliced data can be recorded on film in quantized grey-level form or in color-coded form. For color coding, separations are first prepared, then converted to color images by photographic means. Alternatively, data can be displayed on a color TV screen and the screen photographed. A special processing circuit is used to relate signal strength to mixtures of colors on the TV screen.

2.3.2 FALSE-COLOR FILMS

Another useful processing technique for multispectral data has been the creation of false-color films. In this technique, three single-band images are coded in the three subtractive primary colors: yellow, magenta, and cyan. Since the channels of data used are not restricted to those of the photographic region (0.4-0.9 μm), more information can be presented in this format than is available from conventional color and color-infrared films.

The versatility of the false-color film technique, when applied to multispectral scanner data, stems from the availability of narrower bands over a wider range of spectral data and from the opportunity to optimize the contrast for each band of data before creation of the color composite image. By proper selection of bands and appropriate contrast stretching before color coding, subtle differences in a scene can be enhanced. The color-coding technique can also be used with ratio images to provide a fundamentally different and potentially more useful display than that obtainable from the display of single-band data.

2.3.3 RATIO PROCESSING

Under certain conditions, diagnostic information has been found in the pattern of correlation that exists in the signal level variations observed in two spectral bands for different terrain features. This realization has led to the development of ratio processing, where the signal of one scanner channel (spectral band) is divided by that of another. The object is to enhance the discriminability of scene classes whose mean signal levels are negatively correlated between the two bands. Furthermore, because values of scene irradiance and atmospheric transmission exhibit variations which are highly correlated in adjacent spectral regions, ratioing can be an effective means of signature extension when terrain feature recognition is planned using pattern recognition.

Ratioed data that is to be analyzed directly is presented as a continuous-tone gray image, sliced or combined with other color-coded imagery to make a false color film (see Section 2.3.2).

2.3.4 MULTISPECTRAL SIGNATURE RECOGNITION

Multispectral signature recognition is a computer-implemented data-processing technique for identifying various surface features in multispectral data. Perhaps the most thoroughly studied use of this technique is in the recognition of various crops in agricultural areas, but its utility is not limited to that application. Its use is based on the assumption that the spectral signatures (i.e., the spectral radiances observed by the multispectral scanner in discrete wavelength bands) of various terrain features are sufficiently different to permit recognition of these features by the pattern of their spectral variation.

Typical computer algorithms for recognition require training of the recognition processor. To implement this step, spectral signatures derived from training sets of known terrain classes, or from "clustering" of multispectral data to define separable spectral classes, are fed to the recognition processor. After training (on, typically, a small fraction of the total data set), the processor uses an algorithm to classify the unknown data according to the similarity of a spectral signature to the set of training signatures.

The assumption that the spectral signature of a terrain class is distinctive enough to permit good recognition is crucial to the success of pattern recognition techniques. Also, the conditions of data collection, including illumination, scanner system stability, and atmospheric state must remain fairly uniform to allow good performance. Since in practice, these data collection conditions are only approximately uniform, various preprocessing techniques have been developed to reduce the sensitivity of pattern recognition performance to variations in collection conditions over wide areas. The uniqueness of spectral signatures of terrain classes (under uniform collection conditions) is the fundamental limiting factor in determining the ability of pattern recognition techniques to separate the classes in multispectral data. If two signatures closely resemble each other, the separation of the classes those signatures represent will be difficult. This realization has motivated the search for spectral bands where various terrain classes have different enough signatures to permit their accurate separation. This is termed the optimum spectral bands problem.

2.4 EXAMPLES OF THE USE OF AIRBORNE REMOTE SENSING IN RESOURCE MANAGEMENT

Until recently, natural resource managers were forced to rely on time-consuming and costly ground surveys for obtaining the basic data on environmental conditions which permitted intelligent decision-making. Today, the progressive resource/land manager can obtain most of these essential environmental parameters directly from remote sensing data. Resource managers in nearly all fields have found aerial photography an inexpensive tool that greatly increases the efficiency of their operations. With additional training in the fundamentals of nonphotographic remote sensing techniques, managers may now find whole new areas of survey improvements and environmental parameterization using the new multispectral and radar systems.

The list of potential applications for these new forms of remote sensing is almost endless. Some of these have already been developed to an operational or near-operational stage. The purpose of this section is to illustrate the wide range of opportunities for effectively utilizing multispectral remote sensing through description of applications of new methods that have reached a useful level of development. Hopefully, each reader will find in these descriptions something relating to a management problem, parameter measurement, data analysis capability or location that will provide a hint as to how his or her own work may directly benefit by an investment of interest in this new technology.

2.4.1 AGRICULTURAL CROP MAPPING, ACREAGE DETERMINATIONS AND STRESS DETECTION

In agriculture there are many requirements for information about large areas. The most basic types of information usually required in this regard are identification of crops growing in fields, measurement of the acreage of crops grown in a given area, and predictions of crop yields. The assessment of crop stress (e.g., moisture stress, which could signify the need for irrigation, or the presence of disease) is also an important type of information. By knowing crop acreage, predicted yield, and estimates of yield reduction because of stresses, production estimates can be made.

One of the earliest demonstration applications of the use of airborne multispectral scanner data was in crop identification. Initial experiments were begun in 1964 by ERIM (then the Willow Run Laboratories of The University of Michigan) and Purdue, using data collected with an early version of the M5 scanner system [1, 2]. Since that time Purdue, ERIM, and other experimenters such as USDA-ARS Weslaco and Dr. V.I. Myers (now of South Dakota State University), have continued to develop and refine computer-assisted crop identification, acreage mensuration, and stress detection using airborne multispectral data.

While many of the experiments have concerned the identification and mensuration of Corn Belt agricultural crops (soybeans, corn, winter wheat, oats, etc.), there have been experiments at recognizing rice and safflowers in California, and cotton and sorghum in Southern Texas [1]. The Corn Blight Watch Experiment was a major effort to attempt an assessment of the severity of Southern Corn Leaf Blight in Indiana during the 1971 growing season [3]. All these experiments were conducted using data from the M5 and, in the case of the Corn Blight Watch Experiment, M7 systems. A more recent use of M7 scanner data was to investigate the effects of various numbers of spectral bands, various spectral resolutions, and various radiometric precisions on a multispectral scanner's ability to recognize Corn Belt Crops. This systems-study was done to guide selection of the parameters for the NASA Thematic Mapper, a second-generation spaceborne multispectral scanner [4].

Figure 1 shows 15 spectral bands of multispectral scanner data covering the California Rice Fields area north of Marysville, California. The data were collected at an altitude of 2000 ft on 6/26/66 at 1600 hours. Three basic types of crops are present in Figure 1. Bare soil fields are bright in the blue bands (0.4-0.5 μm). Safflower fields are bright in the near infrared (0.8-1.1 μm) and dark in the blue and red. Mature and immature rice fields appear in intermediate tones in the near infrared. Figure 2 shows recognition of rice, safflowers and bare soil. The maps were prepared on the Special Purpose Analog Recognition Computer (SPARC) using two of the 15 spectral bands available. Good delineation of safflowers, bare soil and immature rice are evident in Figure 2, although the recognition of immature rice within the fields is not complete because of variations in the percentage of rice cover. This first attempt at crop mapping using M5 scanner multispectral data was qualitatively successful, and set the stage for later, more elaborate experiments.

Figure 3 shows a ground information map of crops near Weslaco, Texas. The map shows two types of cotton, sorghum and corn. Multispectral data was collected with the M5 scanner system over this area at an altitude of 2000 ft on 6/30/66 at 1430 hours. Figure 4 shows recognition of the two types of cotton and sorghum. Again, good recognition within the field boundaries and good separation of these crops is observed. These results were also generated by SPARC processing using six bands of data.

With these preliminary promising results and similar results generated at LARS-Purdue in hand, more structured experiments were begun to assess the quantitative accuracy of crop mapping. One of the first of these experiments by ERIM was an attempt to map winter wheat in Indiana [5]. Figure 5 shows the test area near Lafayette, Indiana. Figure 6 shows SPARC recognition of winter wheat using six of the twelve visible-near infrared bands. Two wheat training sets were used to account for some unexpected variations in illumination which occurred randomly in the scene. The accuracy of recognizing wheat in May was 78.0%. The data shown in Figure 6 were collected on 5/6/66 and 6/30/66 at 3500 ft altitude at 1330-1400 hours. At that time of year, the winter wheat was green and presented a dense canopy to the sensor. Some misclassification of oats and green pastures as wheat attest to the potential difficulty of separating these classes with pattern recognition processing of scanner data.

More recently, quantitative experiments with crop recognition have been done at ERIM using selected segments of data from the Corn Blight Watch Experiment and data collected in support of SKYLAB experiments in Michigan [4, 6]. In addition to crop recognition maps, other summaries of system performance were generated in these studies as well. These included tabular statistics or graphs showing performance as a function of the number of spectral channels and of spatial resolution. As an example of the latter type of output, Figure 7 shows the accuracy of recognition of the centers of fields as a function of the number of channels used

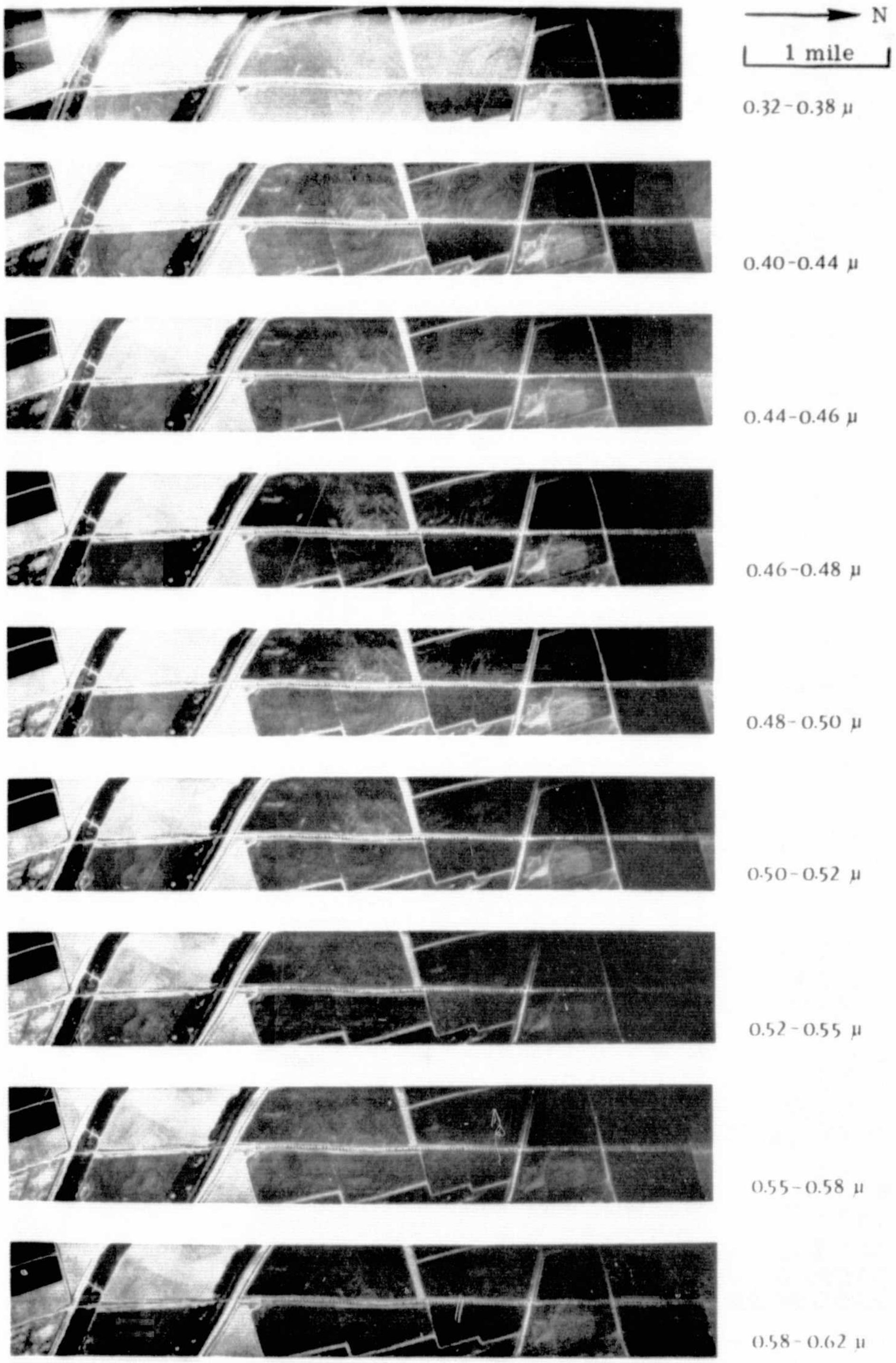


FIGURE 1. MULTISPECTRAL IMAGERY OF DAVIS, CALIFORNIA AGRICULTURAL AREA. 26 June 1966; 1600 hours; 2000 ft (610 m) AGL. (Continued)

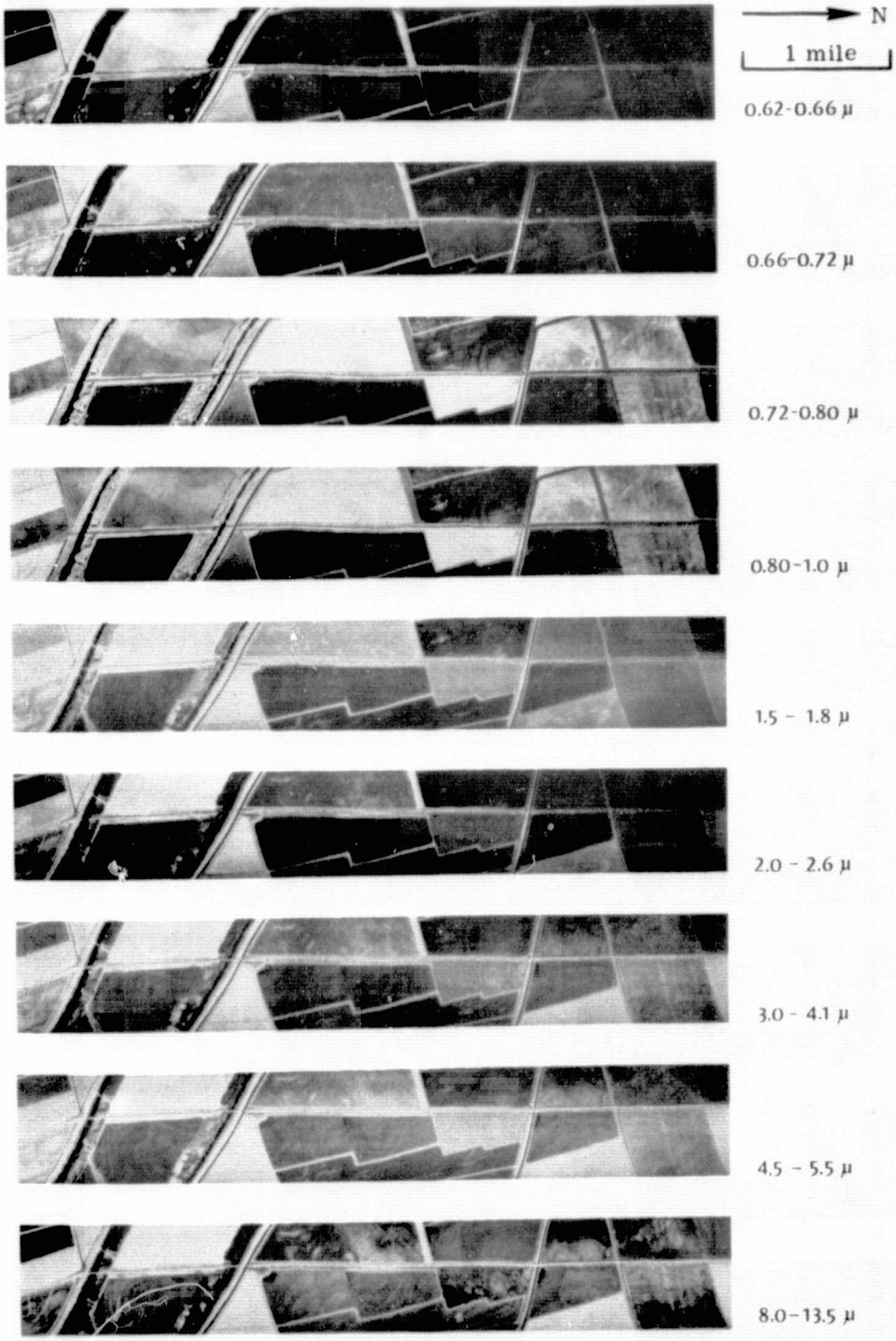
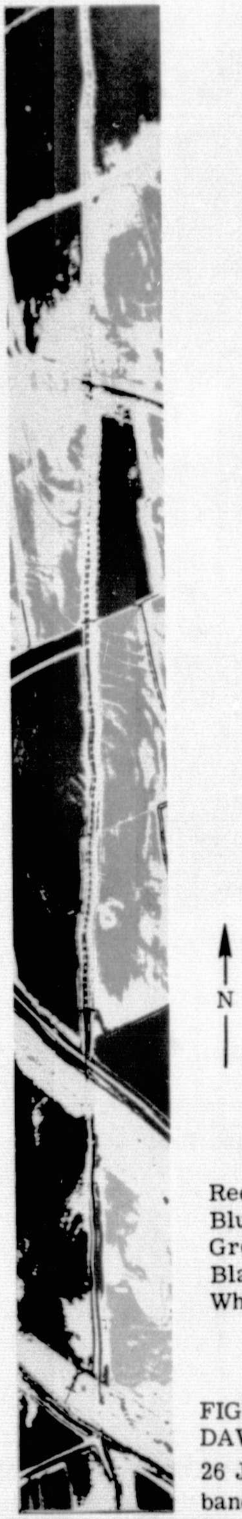


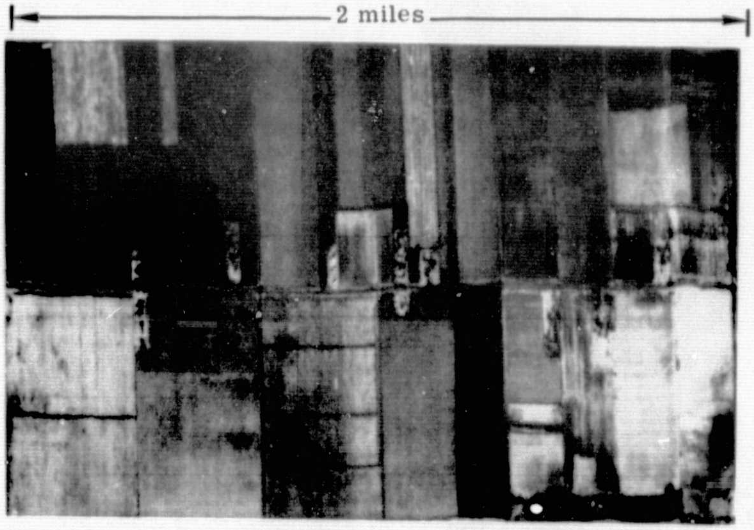
FIGURE 1. MULTISPECTRAL IMAGERY OF DAVIS, CALIFORNIA AGRICULTURAL AREA. 26 June 1966; 1600 hours; 2000 ft (610 m) AGL. (Concluded)



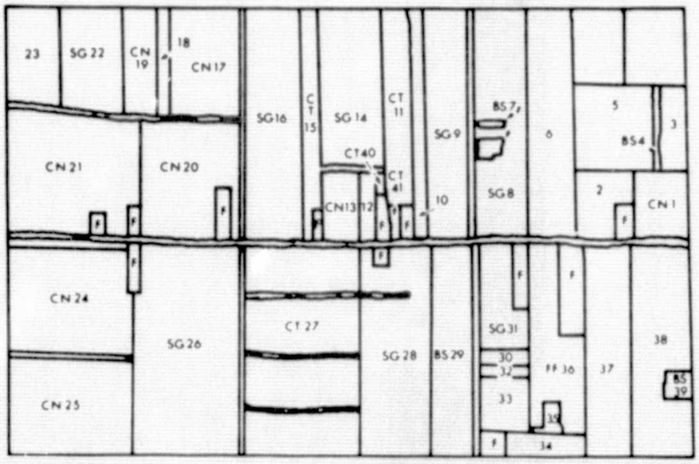
LEGEND

Red	Relatively Mature Green Rice
Blue	Immature Rice
Green	Safflowers
Black	Bare Soil
White	Other

FIGURE 2. CROP RECOGNITION MAP OF DAVIS, CALIFORNIA AGRICULTURAL AREA. 26 June 1966; 1600 hours; 2000 ft (610 m) AGL; bands used: 0.62-0.66 and 0.8-1.0 μm.



(a) 0.8-1.0 μ Video



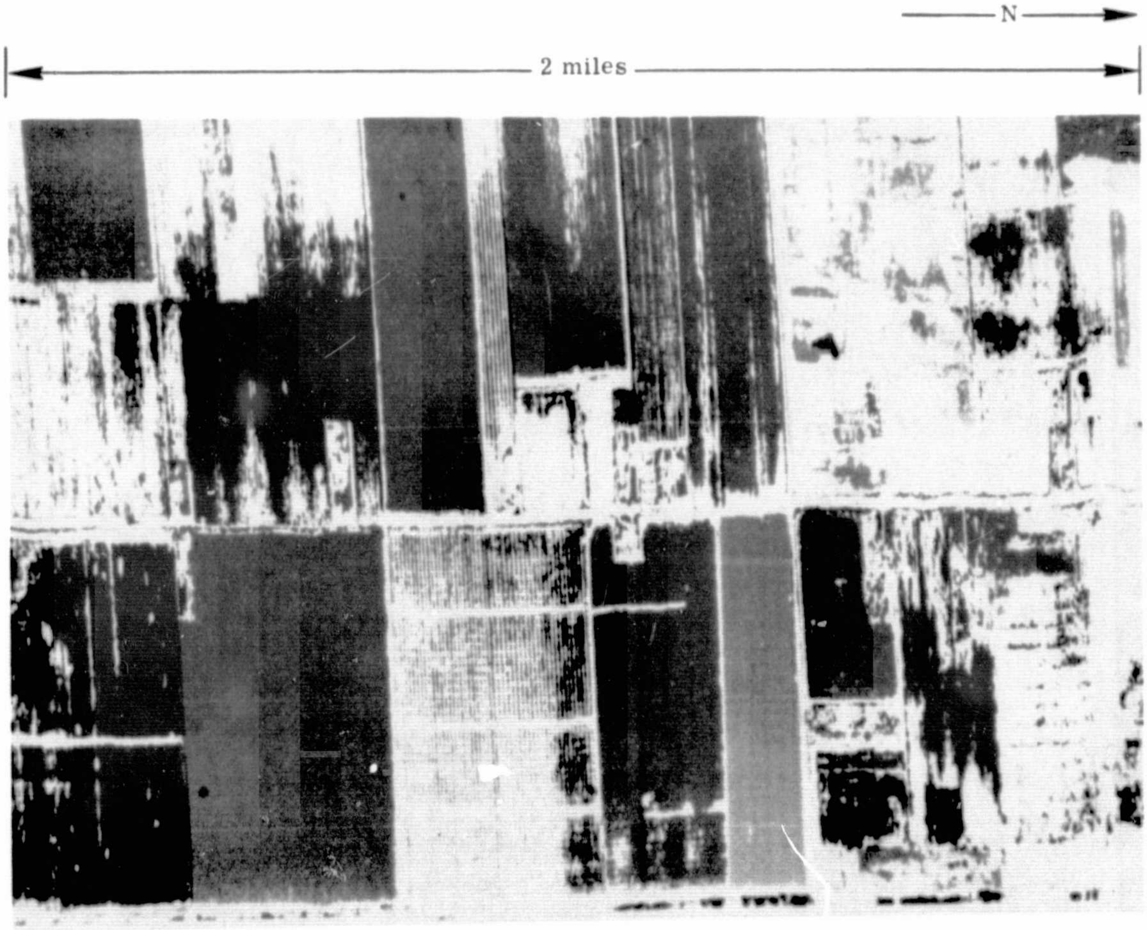
(b) Ground Truth Map

N→

KEY

CN = Cotton
SG = Sorghum
CT = Citrus
BS = Bare Soil
FF = Fallow Field
F = Farmstead

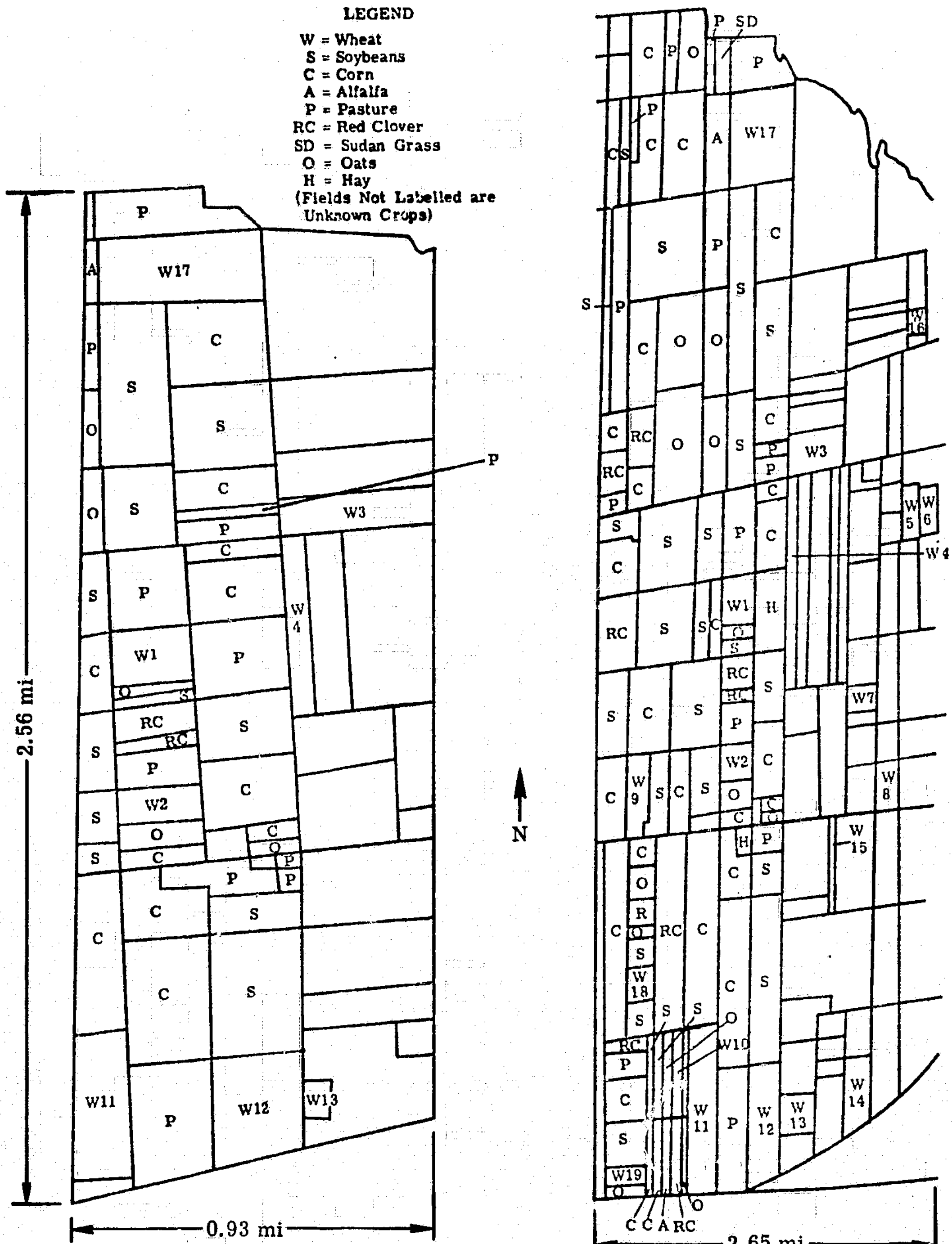
FIGURE 3. VIDEO AND GROUND-TRUTH MAPS OF WESLACO, TEXAS AGRICULTURAL AREA. 30 June 1966; 1430 hours; 2000 ft (610 m) AGL.



LEGEND

Red	Cotton Class 1
Blue	Cotton Class 2
Green	Sorghum
Brown	Bare Soil
White	Other

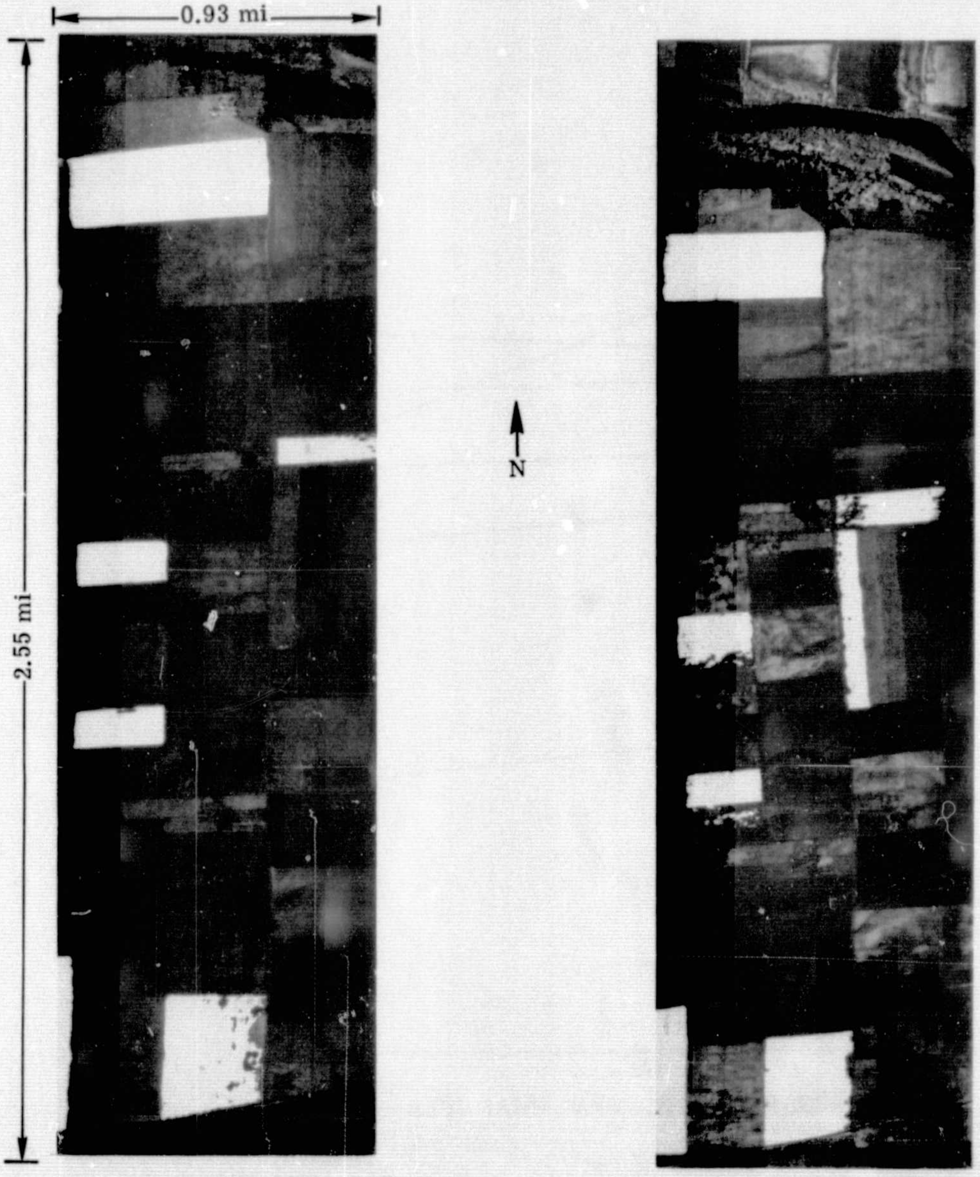
FIGURE 4. COLOR-CODED RECOGNITION MAP OF WESLACO, TEXAS AGRICULTURAL AREA. 30 June 1966; 1430 hours; 2000 ft (610 m) AGL.



(a) 6 May 1966, 3500 ft (1067 m) Data

(b) 30 June 1966, 10,000 ft (3048 m) Data

FIGURE 5. GROUND-TRUTH MAPS FOR DATA COLLECTED NEAR LAFAYETTE, INDIANA



(a) 6 May 1966, 1330 hrs

(b) 30 June 1966, 1400 hrs

FIGURE 6. RECOGNITION OF WHEAT NEAR LAFAYETTE, INDIANA AT TWO DIFFERENT TIMES OF YEAR. Altitude: 3500 ft (1067 m) AGL.

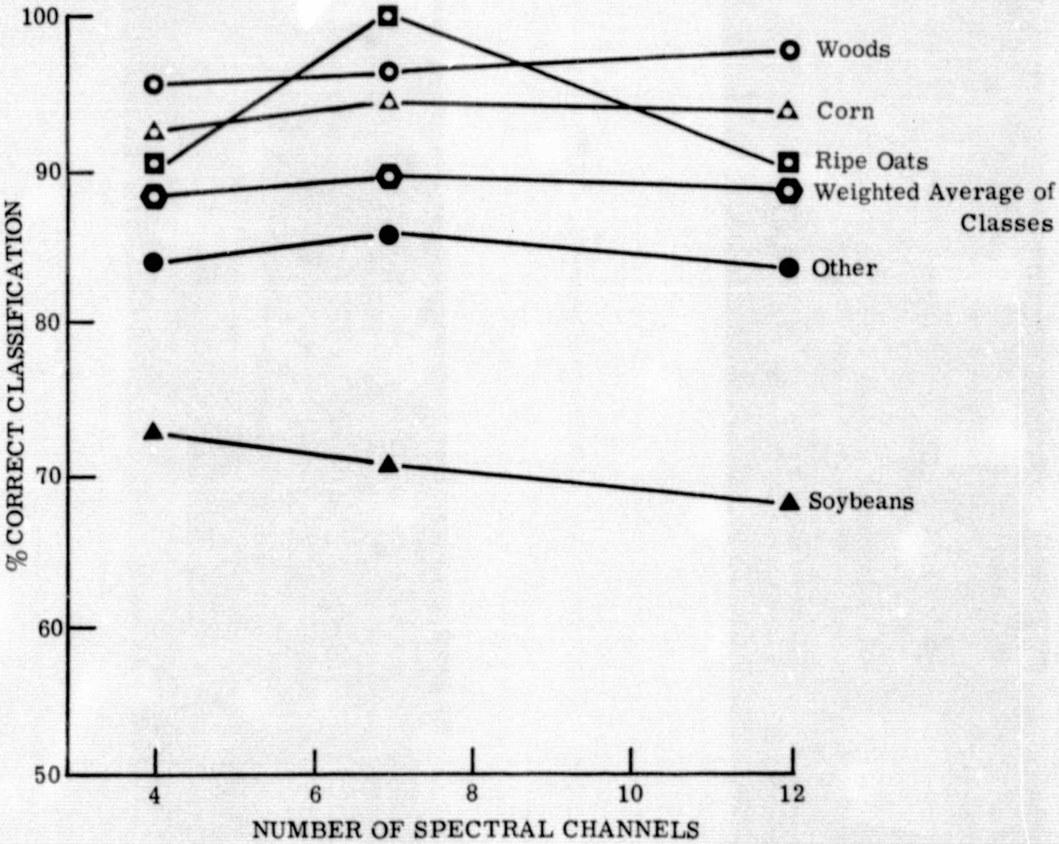


FIGURE 7. CLASSIFICATION ACCURACY VS NUMBER OF SPECTRAL BANDS, MICHIGAN AGRICULTURAL TEST SITE

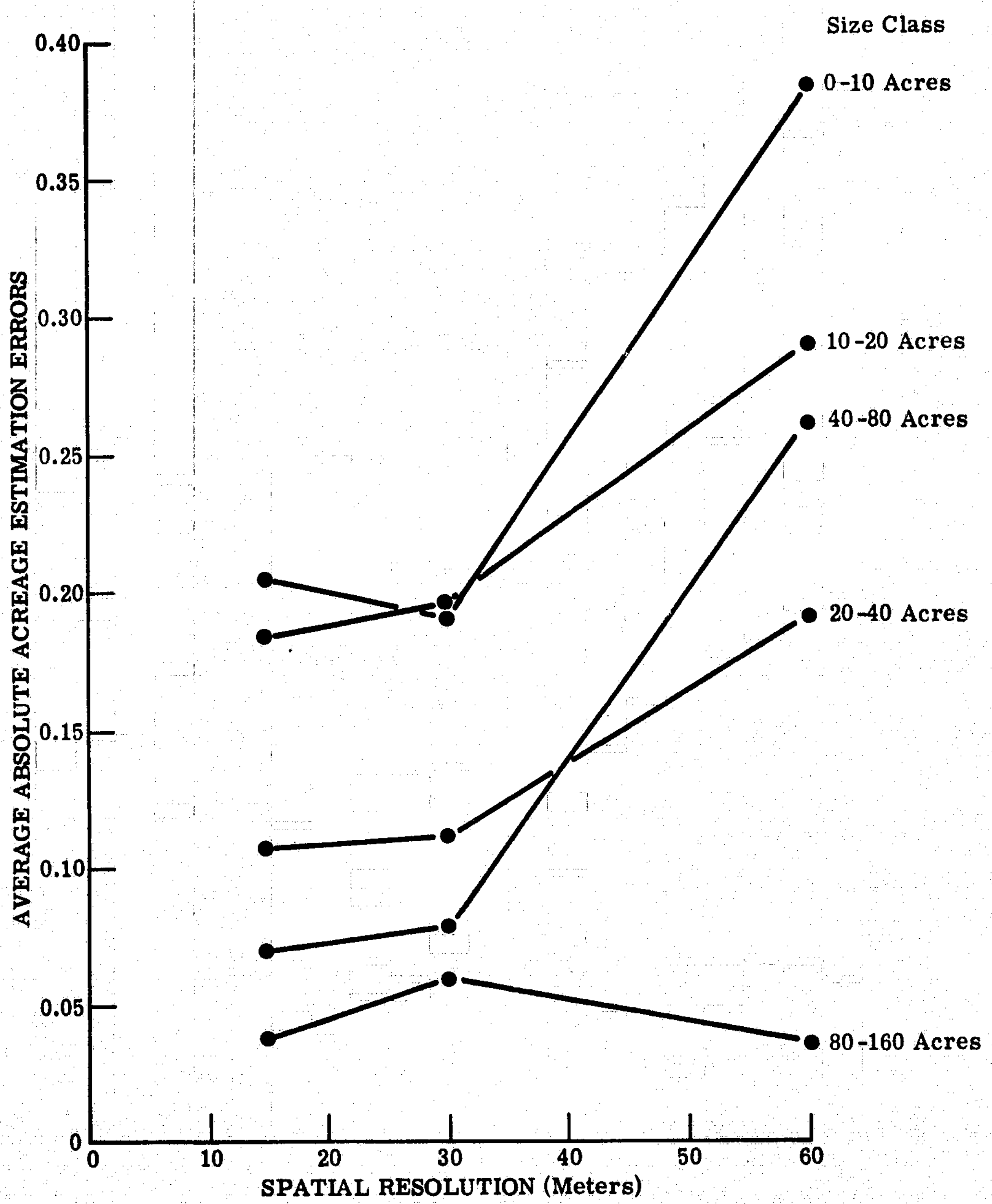
for classification. The results demonstrate that for these data, collected by the M7 at 1030 hours on 8/5/73 at an altitude of 10,000 ft, four-channel recognition of the crops studied - corn, oats and soybeans is nearly as good as twelve-channel performance. (It should not be inferred from this, however, that the four channels used, 0.62-0.70, 1.5-1.8, 0.41-0.48 and 0.67-0.94 μm, are optimum for other crops at other times in the growing season.) Figure 8 shows the acreage mensuration accuracy for fields of varying sizes as a function of the spatial resolution of digital data. The different spatial resolutions were simulated by averaging samples of digitized data. Because digital scene elements containing field boundaries are often, but not always misclassified, acreage mensuration accuracy was found to decrease as the spot-size resolution of the data increased relative to the field size. The effect is most drastic for small fields. These quantitative results of crop classification and mensuration accuracy wer[illegible]d in the selection of bands and spatial resolution for the Thematic Mapper, which may be flown on the EOS satellite in the 1980's.

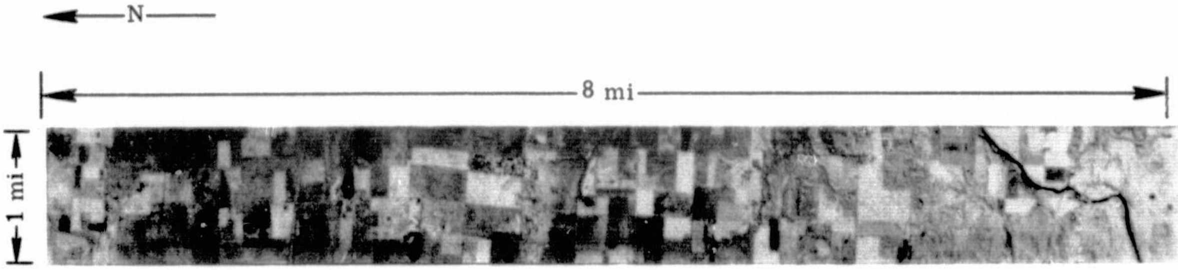
The Corn Blight Watch Experiment, conducted in 1971, was the first large-scale attempt to map the development of a crop stress during the growing season. In this experiment, periodic coverage was essential for accurate monitoring of blight development. A camera in the NASA RB-57 aircraft collected color-infrared photography every two weeks during the growing season for sample segments which spanned nearly the entire U.S. corn-producing area. Aircraft multispectral scanner data were collected by the ERIM scanner system in mid-May; and bi-weekly from late June through mid-October over 30 segments from northern to southern Indiana. Extensive ground information was also gathered by USDA personnel and by investigators from ERIM and LARS.

Pattern recognition techniques were used to map blight severity. Fifteen 1 × 8-mile strips of data were processed every two weeks at ERIM on the SPARC computer. As an example of the SPARC-processed data, Figure 9 shows 0.67-0.94 μm imagery and processed data of segment 212, near Crawfordsville, Indiana. Also shown in Figure 9 is color-coded recognition of two classes of corn blight - mild blight (levels 0-3) in green and severe blight (levels 4 and 5) in red. The blight levels were coded 0-5 representing no blight to severe blight. It was the conclusion of the Corn Blight Watch Final Report [3] that the two classes of blight shown in Figure 9 were at least as accurately mapped by the computer processing of airborne multispectral data as with photointerpretation of high-altitude color-infrared photography.

2.4.2 EARLY DETECTION OF FOREST DAMAGE

Each year as much as 50% of the timber volume added by annual growth to the forests of the United States is destroyed by insect pests and tree diseases [7]. In addition to the timber actually destroyed by these forest enemies, their actions also result in reduced growth and


Size Class
0-10 Acres
10-20 Acres
40-80 Acres
20-40 Acres
80-160 Acres
AVERAGE ABSOLUTE ACREAGE ESTIMATION ERRORS
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
0
10
20
30
40
50
60
SPATIAL RESOLUTION (Meters)



(a) 0.72-0.92 μm Imagery

(b) Color-Coded Recognition Map

Color	Material	Optimum Channels (μm)
Green	Corn, blight levels 0-3	0.50-0.54
Red	Corn, blight levels 4 and 5	0.58-0.65
White	Not recognized	0.66-0.76
		1.0-1.4
		9.3-11.7

FIGURE 9. COLOR-CODED RECOGNITION MAP OF CORN BLIGHT NEAR CRAWFORDSVILLE, INDIANA. 17 August 1971; 1030 hrs.

impaired wood quality in the remaining trees. In the worst situations land may even be left completely unstocked by desirable tree species.

In most cases, effective control or suppression of these destructive agents is dependent largely on early detection of their presence. Unfortunately, this is all too frequently impossible. One reason for this is the extensive and remote nature of the susceptible area. Another is the fact that the reconnaissance surveys required for effective early detection of pathogen activity would have to be added to the already formidable work load of field personnel.

This means foresters must depend on incidental reports of tree damage and identification of causal agents, carried out by field personnel either in addition to their regular duties, or in response to the request of a concerned landowner who has noticed an unusual condition. By this time, however, it may be too late to control or suppress the situation. The damage syndrome may have covered too extensive an area or may be at a developmental stage that will not respond to treatment; the particular time of year may also make it impossible to solve the problem. In the long run this results in an increased loss of forest resources, a compounded salvage problem, and usually greater costs for control or suppression when it is feasible.

The use of aerial reconnaissance surveys employing either trained observers [9] or photointerpretation techniques [10, 11, 12] is a partial answer to the enormous surveillance and assessment task this problem poses. Large and/or remote areas can be surveyed from an airplane for a fraction of the cost of using field techniques. Yet for several of the more important types of forest damage, these advantages have not been realized, since investigations have shown that damage still cannot be spotted early enough to permit effective remedial action; the period of time required for specific organizational response still exceeds that margin gained by the use of aerial detection methods.

There is, nevertheless, hope for improving upon existing methods of aerially detecting incipient damage by two of the more destructive groups of damage-producing agents, bark beetles and root-rotting fungi. While these organisms are dissimilar in nature and mode of attack, the manifestations of the damage they cause to individual trees share certain common characteristics. Following an attack by either agent, the first serious physiological effect of the stress induced in the host tree is an interruption of the water transport mechanism between its roots and the leaves. A system capable of sensing the manifestations of this moisture stress might provide the early warning of infestation or infection that is required.

In laboratory experiments, Rohde [13] measured an increase in mid-infrared (1.0-2.6-μm) reflectance in Fomes annosus* infected needles of red pine. It is significant that this change

*A root-rotting fungus.

was observed before any visible change became apparent in the foliage. Since imaging capabilities of the multispectral scanner (MSS) permit it to collect data in the critical mid-infrared portion of the spectrum, which is beyond the photographic region, it appears that the MSS may possess the potential to improve aerial forest damage surveys involving these pathogens.

As an empirical test of this hypothesis, data were collected over a NASA forestry study site near Ann Arbor, Michigan, in June of 1970 and 1972 [14]. The study site is comprised of three distinct stands of conifers, each approximately 35 years old. Eastern white pine and red pine are planted separately and cover most of the area, but a small stand of mixed hemlock and spruce is also present (Figure 10).

The multispectral data were collected at an altitude of 1500 ft, providing an effective ground resolution of 4 ft^2.

Olson (Principal Investigator) and Roller (MSS Data Processing Task Leader) realized that before a MSS could ever become a practical alternative method of conducting forest damage surveys, any data processing procedures and analysis strategies developed must overcome several important criticisms. These included:

1. the high costs associated with MSS data collection and processing;
2. the complex nature of this technology, which makes it a high-risk survey technique; and
3. the abstract appearance of the computer-generated results (either statistics or line-printer portraits of a study site), which requires special training before it can be correctly interpreted.

With particular regard to this last issue, it was recommended that, in the design of the system, the ability to make ready comparisons between MSS results and photographs and maps should be a high priority.

The ratio-processing technique developed for this application and illustrated in Figure 11 shows promise in meeting all these criteria. In the ratio-processed MSS data, the study site still appears much as it would in a conventional black and white photograph; the only difference is that the tonal values are reversed from those which we normally encounter. In this imagery hardwoods are very dark, while conifers are light. The two MSS data channels ratioed were a near-infrared (NIR) spectral band, 1.0-1.4 μm, and a near-infrared (NIR) band 2.0-2.6 μm. It was hoped that by ratioing it would be possible to enhance the appearance of trees with an increased reflectance in the 2 μm region, due to water stress, yet with normal 1 μm reflectance, because no changes in needle morphology had yet occurred.

Six tonal anomalies were found in the processed MSS imagery. These are the darker areas within the conifer stands indicated by the arrows in Figure 11. Comparison with the photointerpretation results shows that four of these anomalies are the known infection centers detected

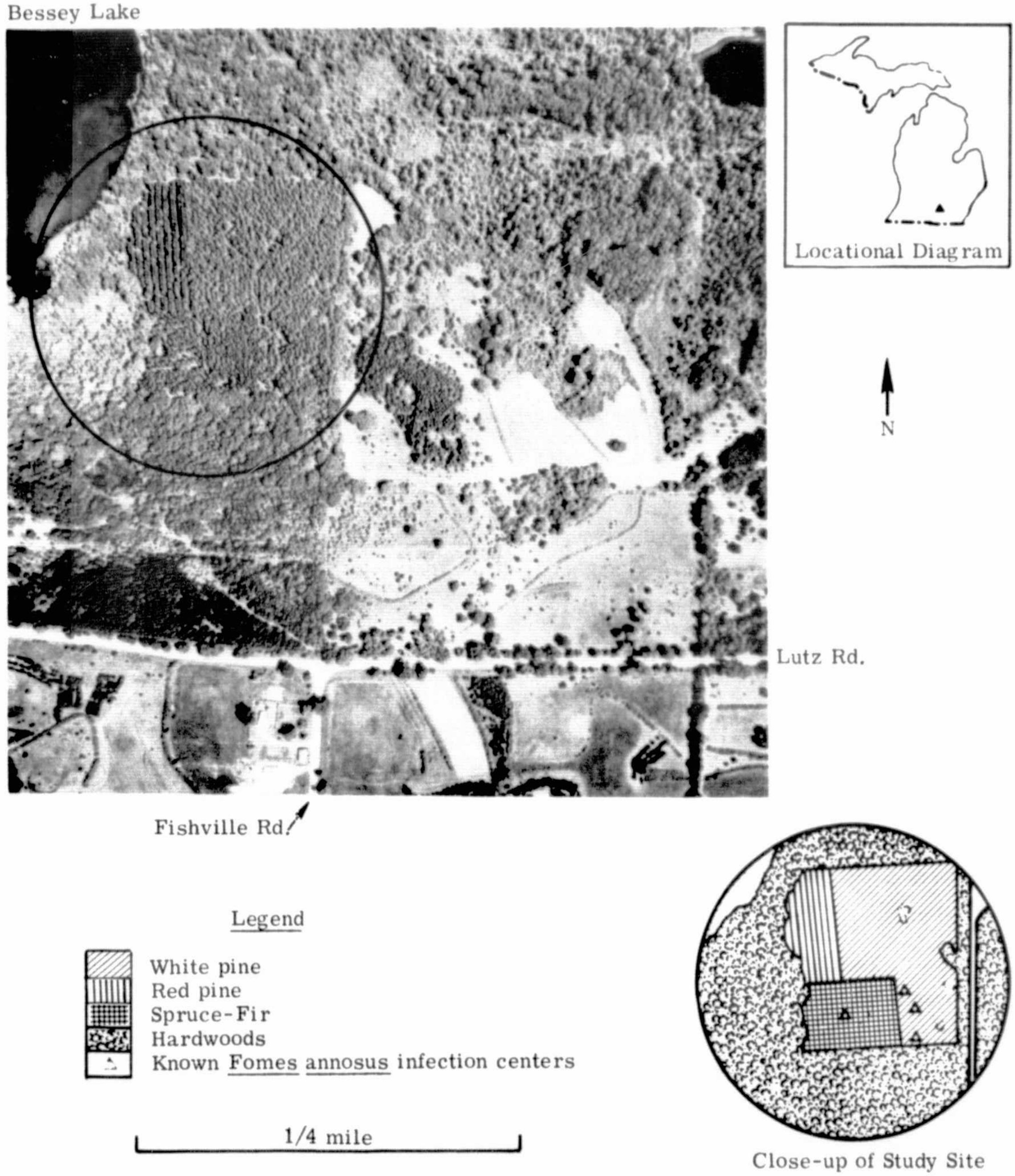


FIGURE 10. FOREST DAMAGE DETECTION STUDY SITE, SHARONVILLE STATE GAME AREA, JACKSON COUNTY, MICHIGAN. The original color infrared photography is 70 mm format and was collected on 5 June 1972 at 1100 hrs, 3000 ft (914 m) AGL.

using photointerpretation methods. All of these known infection centers were characterized by holes in the canopy, actually dying trees, through which the litter of the forest floor was visible.

Very close scrutiny of the photography in the vicinity of the two additional anomalies resulted in the detection of the presence of one small dead tree and one which was highly faded (yellow-green foliage) in the area of anomaly 6, and no visible damage in the region of anomaly 3.

Examination of these areas on subsequent photography, collected two years later during a repeat survey in 1972 (Figure 12) shows that both have developed into new infection centers (field verified). This indicates the value of a MSS data enhancement technique for use in forestry work. Both of these areas would have been unnoticed for two more years if the MSS data had not focused attention on them. It is precisely this type of early detection of pathogen activity that will give foresters the time they need to be able to provide adequate protection for our forest resources.

In an operational survey, strip film imagery of this type could be generated using a wet processor in-flight, and be ready for interpretation upon landing or for immediate distribution to field-checking crews. The job of a forester-image interpreter would then be to scan each plantation or stand for obvious tonal anomalies. Only these anomalies need then be checked on the ground.

2.4.3 WATERFOWL HABITAT ASSESSMENT

Each year the opportunity to observe migratory waterfowl returning to their northern breeding grounds in the spring, and then to hunt them in the fall as they once again head south, offers millions of Americans countless days of satisfying outdoor recreation [15]. In turn, sportsmen and others who enjoy the outdoors contribute to the perpetuation of this renewable resource through revenue collected by the federal government from both the sale of duck stamps and taxes on the sales of firearms and ammunition.

The agency responsible for the protection and management of migratory waterfowl is the United States Fish and Wildlife Service in the Department of the Interior. Their research has shown that annual populations of migratory waterfowl, unlike resident small-game species (e.g., jack rabbits and pheasants), can be greatly influenced by hunting pressure [16]. Largely, this is a result of the fact that hunting is the <u>major</u> cause of mortality among the young of the year for many species of waterfowl, although changes in weather and the water conditions of the wetlands in the breeding grounds are also important [17, 18]. What this means is that proper management of migratory waterfowl requires an <u>annual</u> adjustment of hunting regulations to insure that a sufficient number of birds remain after the hunting season to provide for production the following year.

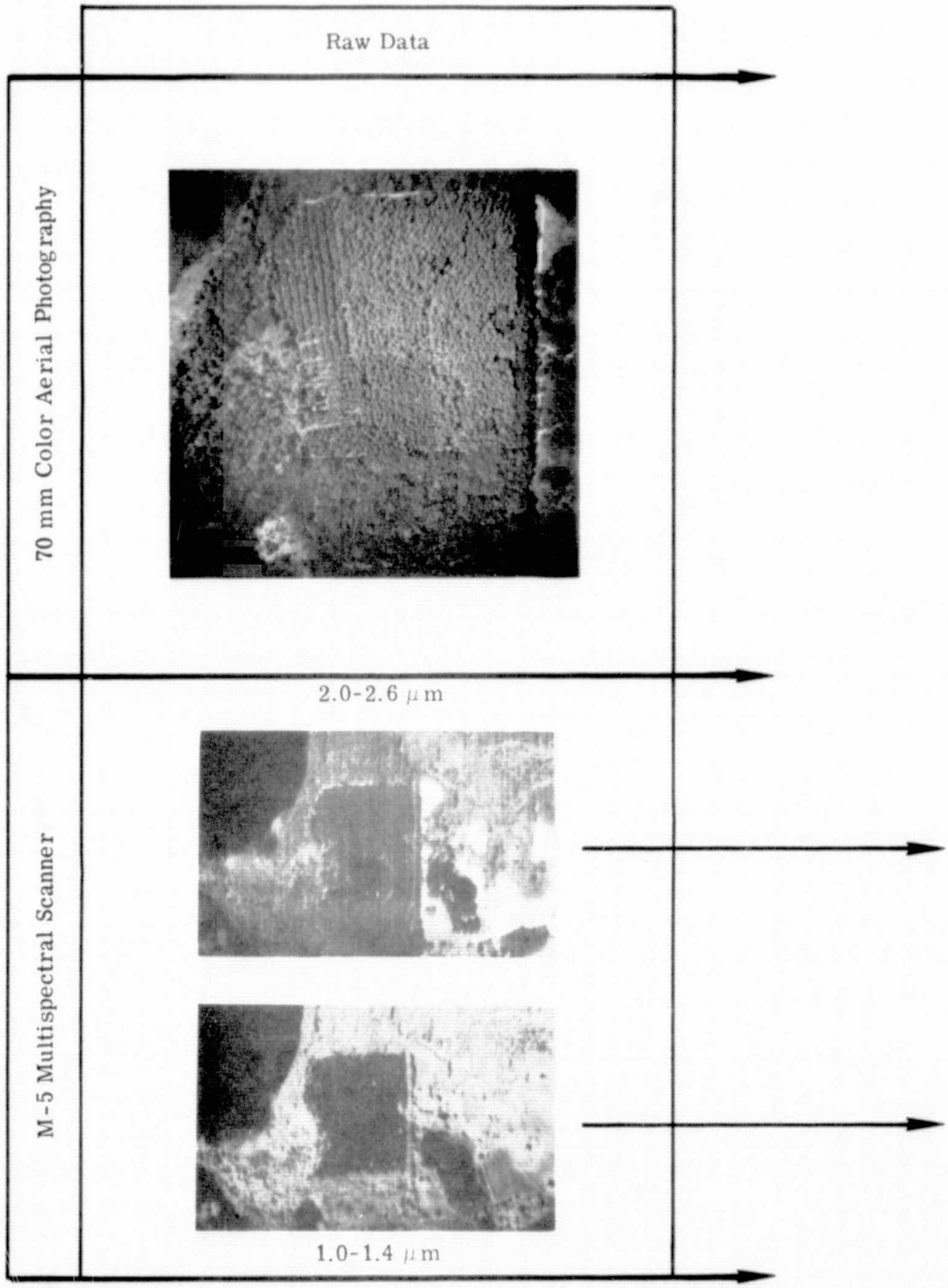
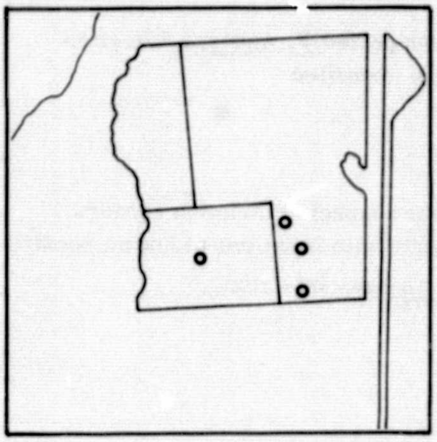


FIGURE 11. 1970 FOMES ANNOSUS DAMAGE DETECTION SURVEY. Multispectral data and 70 mm color aerial photography collected on 6 June 1970 at 0930 hrs, 1500 ft (457 m) AGL. (Continued)

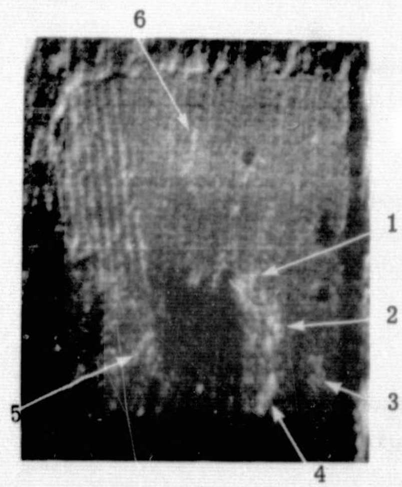
Data Processing

Method: Stereoscopic Photo-Interpretation



Circles indicate location of suspected infection centers.

Method: Ratio processing of near and mid-IR data

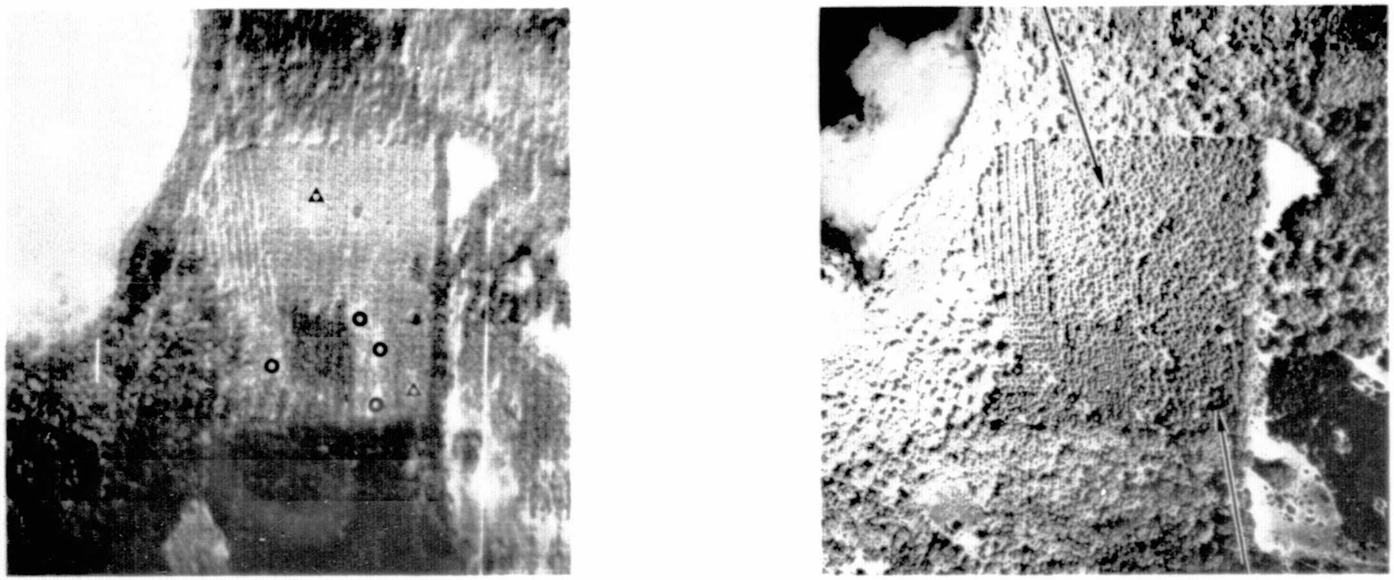


Anomolous areas indicated by arrows

FIGURE 11. 1970 FOMES ANNOSUS DAMAGE DETECTION SURVEY. Multispectral data and 70 mm color aerial photography collected on 6 June 1970 at 0930 hrs. 1500 ft (457 m) AGL. (Continued)

Results
• Four suspected F. Annosus infection centers identified • All four suspected infection centers correlate with locations of known pockets of F. Annosus infection.
• Six anomalous areas identified • Four of the anomolous areas correlate with locations of known pockets of F. Annosus infection. • Two additional anomolous areas remain to be correlated with further work.

FIGURE 11. 1970 FOMES ANNOSUS DAMAGE DETECTION SURVEY. Multispectral data and 70 mm color aerial photography collected on 6 June 1970 at 0930 hrs, 1500 ft (457 m) AGL. **(Concluded)**



(a) MSS Data Processing Results, 1970 Survey

o - known infection centers

△ - suspected infection centers

(b) Color Infrared 70 mm Photography, June 1972 Survey

Arrows indicate new holes in the canopy and fading trees (blue crowns), which confirm 1970 MSS Survey results.

FIGURE 12. FOMES ANNOSUS DETECTION: COMPARISON OF 1970 MSS SURVEY WITH 1972 PHOTOGRAPHIC SURVEY. The color infrared photography was collected on 5 June 1972 at 0930 hours, 1500 ft (457 m) AGL.

In order to set appropriate hunting regulations, accurate estimates of the current year's recruitment for the populations of the different species of waterfowl must be available at the time these regulations are established. Since the regulations are set in late summer, before the migration actually begins, a critical need thus exists to be able to accurately predict the size of the fall flight from the breeding grounds.

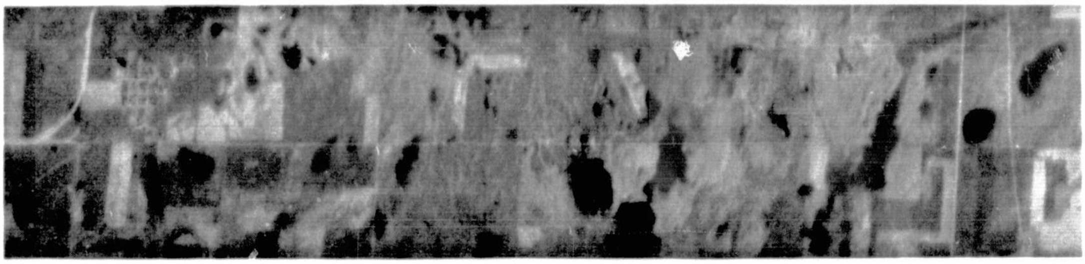
To meet this need, over the past twenty years the United States Fish and Wildlife Service (USF&WS), in cooperation with the Canadian Wildlife Service (CWS), has developed systematic aerial inventory procedures for predicting fall waterfowl populations [19, 20]. Aerial transects are flown in May and July to gather information relating to sizes of breeding populations, habitat condition, and estimates of waterfowl production. Limited ground samples are then used to obtain correction factors for the large body of aerial data, and the adjusted results used for reaching management decisions.

A problem inherent to the above procedure is one of timeliness. Predictions regarding the fall waterfowl flight must be available to the various flyway council meetings held in early August, when the bag limits and season lengths are established for the fall hunting period. Aerial surveys, however, often are not completed until the end of July. As a result, wildlife biologists are hard-pressed to evaluate and develop the necessary recommendations in time to meet this annual deadline.

Recently, biologists have suggested that a reliable brood-production index could be derived for several species of migratory waterfowl in the glaciated prairies and parklands of the mid-continent from a comparison of the number of wetlands characterized by open surface water ("ponds") existing in May and July, and independent of the actual size of the breeding population [17]. Because water can be easily recognized using a single near-infrared wavelength band of data, the use of an airborne scanner system to record the terrain's appearance and a machine processor to analyze the electronically recorded signal should provide a very efficient means of gathering and analyzing data on surface water presence and distribution.

The United States Fish and Wildlife Service (Northern Prairie Research Station) and ERIM conducted joint studies between 1968 and 1972 to establish the feasibility of this approach, and to determine optimum data collection and processing strategies and systems [21, 22]. The imagery that follows illustrates the results and procedures developed during this work: (1) raw video data collected by the scanner (Figure 13); (2) the intermediate data processing step in which the ponds are delineated (Figure 14); (3) the final step, in which summary statistics describing the frequency and distribution of the ponds counted are tabulated (Figure 15).

The advantages found to be gained using the MSS system are several. First, a uniform criteria is employed for detecting ponds and delineating their areas and perimeters. Second, area, perimeter and shape measurements can be made more rapidly using a computer than by



(a) 1.5-1.8 μm, Raw Analog Imagery

(b) Level Sliced Water Recognition Map, 1.5-1.8 μm, Digital Imagery

N

FIGURE 13. POND DETECTION ACCOMPLISHED BY THRESHOLDING 1.5-1.8 μm DATA. 31 July 1970; 0955 hours; 4500 ft (1372 m) AGL; Woodward, North Dakota Study Area.

(a) May Distribution of Ponds

(b) July Distribution of Ponds

FIGURE 14. CHANGES IN POND AREA BETWEEN MAY AND JULY DETECTED IN PROCESSED DATA. Woodward, North Dakota study area; 2000 ft (610 m) AGL, 1.5-1.8 μm data.

```
PROJ. 03398-H,N. DAKOTA, 22 MAY 1970, 1105, 1.5-1.6 MICRONS, LINE 1, 2K FT
LINES18400 THRU19000, POINTS 130 THRU 248

ALTITUDE= 2100.FT  VELOCITY= 207.FT/SEC  SCAN RATE=65.5 RPS  RESOLUTION= 5.35 MRAD  ONE SCANLINE IN 2. DIGITIZED
 NADIR AT POINT NO.189  POINTS COUNTED IF VOLTAGE LIES BETWEEN   0 AND 1.20 VOLTS
 NB= 0  NC= 1  SPTH= 5.82 FEET
```

SCAN LINE	POINT	AREA (ACRES)	PERIMETER (FEET)	SHAPE *
18414	150	.119	306.734	1.063
18461	162	.279	418.794	.950
18475	192	.052	259.766	1.362
18487	231	.116	272.230	.959
18515	150	.328	456.598	.956
18563	190	.121	340.322	1.174
18565	172	.481	603.448	1.043
18569	226	1.528	1493.685	1.447
18620	130	.050	169.165	.904
18721	162	3.418	2254.672	1.461
18733	179	.067	239.502	1.107
18768	172	.072	271.878	1.213
18774	135	.502	584.780	.988
18815	248	10.515	6193.072	2.288
18872	135	.569	620.947	.986
18875	170	.730	932.161	1.307
18914	198	.360	494.842	.988
18929	130	.757	895.891	1.109
18996	239	.496	629.921	1.071

```
PROJ. 03398-H,N. DAKOTA, 22 MAY 1970, 1105, 1.5-1.8 MICRONS, LINE 1, 2K FT
LINES18400 THRU19000, POINTS 130 THRU 248
```

AREA DISTRIBUTION (ACRES)		PERIMETER DISTRIBUTION (FEET)		SHAPE DISTRIBUTION	
.05 TO .10	4	0 TO 330.	6	0 TO 1.00	7
.10 TO .20	3	330. TO 660.	8	1.00 TO 1.10	3
.20 TO .30	1	660. TO 990.	2	1.10 TO 1.20	3
.30 TO .40	2	990. TO 1320.	0	1.20 TO 1.30	1
.40 TO .50	2	1320. TO 1650.	1	1.30 TO 1.40	2
.50 TO .60	2	1650. TO 1980.	0	1.40 TO 1.50	2
.60 TO .70	0	1980. TO 2310.	1	1.50 TO 1.60	0
.70 TO .80	2	2310. TO 2640.	0	1.60 TO 1.70	0
.80 TO .90	0	2640. TO 2970.	0	1.70 TO 1.80	0
.90 TO 1.00	0	2970. TO 3300.	0	1.80 TO 1.90	0
1.00 TO 2.00	1	3300. TO 3630.	0	1.90 TO 2.00	0
2.00 TO 3.00	0	3630. TO 3960.	0	2.00 TO 2.25	0
3.00 TO 5.00	1	3960. TO 4290.	0	2.25 TO 2.50	1
5.00 TO 10.00	0	4290. TO 4620.	0	2.50 TO 2.75	0
10.00 TO 15.00	1	4620. TO 4950.	0	2.75 TO 3.00	0
15.00 TO 20.00	0	4950. TO 5280.	0	3.00 TO 3.25	0
OVER 20.00	0	OVER 5280.	1	OVER 3.25	0

FIGURE 15. TYPICAL DIGITAL COMPUTER PRINTOUT OF POND STATISTICS.
22 May 1970; 1013 hours; 2100 ft (640 m) AGL; Woodward, North Dakota study area; 1.5-1.8 μm data.

* Pond Shape is defined as $\frac{\text{Perimeter}}{4\pi\ \text{area}}$. Waterfowl managers are interested in pond perimeter and shape because it influences the number of breeding pairs that can occupy an area. Irregularly shaped ponds can provide more shoreline suitable for breeding, all other conditions being equal.

hand; computers also permit the display of summary statistics quickly and easily according to several different tabulation schemes. Finally, the increased efficiency with which the resource can be inventoried makes it possible to analyze a larger area, thus increasing the sample size and, hopefully, improving the accuracy of the production index.

Present research efforts are involved with investigating the feasibility of using satellite data to provide an additional dimension to the synoptic nature of this approach to the problem of waterfowl habitat inventory [23]. Results of this research may indicate a combined satellite/aircraft program as the most efficient method of getting the essential survey data.

2.4.4 REGIONAL GEOLOGY INTERPRETATION

Geology represents a particularly suitable application of modern remote sensor data for several reasons. These include the need for large-area spatial terrain information, the varying spectral reflectance and emittance characteristics of geological materials, and the general acceptance in the past of aerial photography as an important part of geological exploration and mapping. This last reason has allowed geologists to readily perceive the value of extending established techniques of photo-geology to newer types of remote sensor data. With these new types of imagery the geologist is able to discern and identify terrain patterns of useful geologic detail which are either very subtle or absent in aerial photos.

Data from two different test sites provide examples of some of the geologic information available with modern imaging sensors: multispectral, thermal IR, and radar. The two sites are (1) the alluvial fan and fault zone along the base of the Stillwater Range in west-central Nevada, and (2) the volcanic terrain of the Pisgah Crater area in southern California. The fact that both of these sites are in arid climates maximizes the surface exposure of geological materials. The Stillwater Range was one of the earliest geological sites flown with the M5 scanner system (25 June 1966) and Pisgah Crater has been recorded on four different multispectral and radar missions, commencing in 1967.

The Stillwater Range, like most ranges in the Range and Basin Province, was formed by tectonic uplift along steeply dipping normal faults of Cenozoic to Recent age. Indeed, recent earthquakes indicate that the fault zones are still active. In places these faults have resulted in scarps several feet high which commonly traverse the alluvial fans at the base of the ranges, interrupting drainage patterns, blocking roads, and providing evidence of the fault locations [24]. The accurate detection and mapping of the major fault traces and zones provides an important key to understanding the structural geology of an area and is a prerequisite to the current interest in earthquake prediction. The continuous strip format and spectral detail of multispectral images is used to advantage in recording and enhancing these narrow linear terrain patterns.

Figure 16 compares three multispectral images of the fault zone along the eastern edge of the Stillwater Range. Image (a) is a reflective infrared image recorded in the 1.5 to 1.8 μm range. In this spectral band many of the surface drainage details and a road track across the valley alluvium may be discerned. Image (b) is recorded in the 4.5 to 5.5 μm thermal range and shows grey tones associated with different alluvial materials. Image (c) is a ratioed image of two infrared spectral bands in which the fault trace along the base of the Stillwater Range can be easily perceived. This trace, evident on image (a) as well, is formed by a series of scarps, twelve feet high or more, in the alluvium. Comparing the images with data recorded in the visible wavelengths, it was concluded that the reflective and thermal infrared data provided better image contrast of terrain scarp patterns in these fault zones. Indeed, the fact that the scarp appears dark in the reflective IR and warm (light) in the thermal IR allows its location to be enhanced in the ratio image.

From a hydrologic perspective the differentiation of alluvial materials in this arid environment may provide evidence of sources and flow directions of subsurface water. Figure 17 compares three images which, successively from top to bottom, provide better delineation of the alluvial materials at the base of the Stillwater Range. The upper image shows contrasts in the 0.8 to 1.1 μm range which are very similar to those observed in the visible range. In other words, it is unlikely that aerial photography which records in the visible and near IR wavelengths would provide better differentiation of the alluvial materials than is shown in this image. The middle image was recorded in the 1.5 to 1.8 μm range and shows many of the fine details of the incised channels caused by ephemeral streamflow across the fans which are not apparent in the upper image. The lower image is a ratio of the 3.0 - 4.1 μm and the 1.5 - 1.8 μm bands. This image clearly differentiates the extent and general orientation of these alluvial fans and confirms other observations that the near-IR spectral range provides unique discrimination of geological features [25]. Near the base of the fans is the Humbolt Salt Marsh, a salt marsh playa. The ground water is provided to this marsh from the Stillwater Range through the alluvial fans shown, and is also affected by the tectonic activity of this area.

Pisgah Crater, California, has been the site of a number of geological investigations utilizing remote sensor data. Its selection provided good exposures of a variety of lithologic materials—including lava flows of different ages and surface textures, felsic materials, and recent gravels and alluvium [26]. Almost no vegetation in this arid area obscures the geologic materials.

Figure 18 shows three thermal infrared images from a study of the Pisgah Crater area, two of which appear similar in contrast [27]. The third image is a ratio of the first two and shows relative differences between them. Each image shows an area of approximately 0.8 by 5.5 miles. Several features are worth noting. The two similar images were obtained from

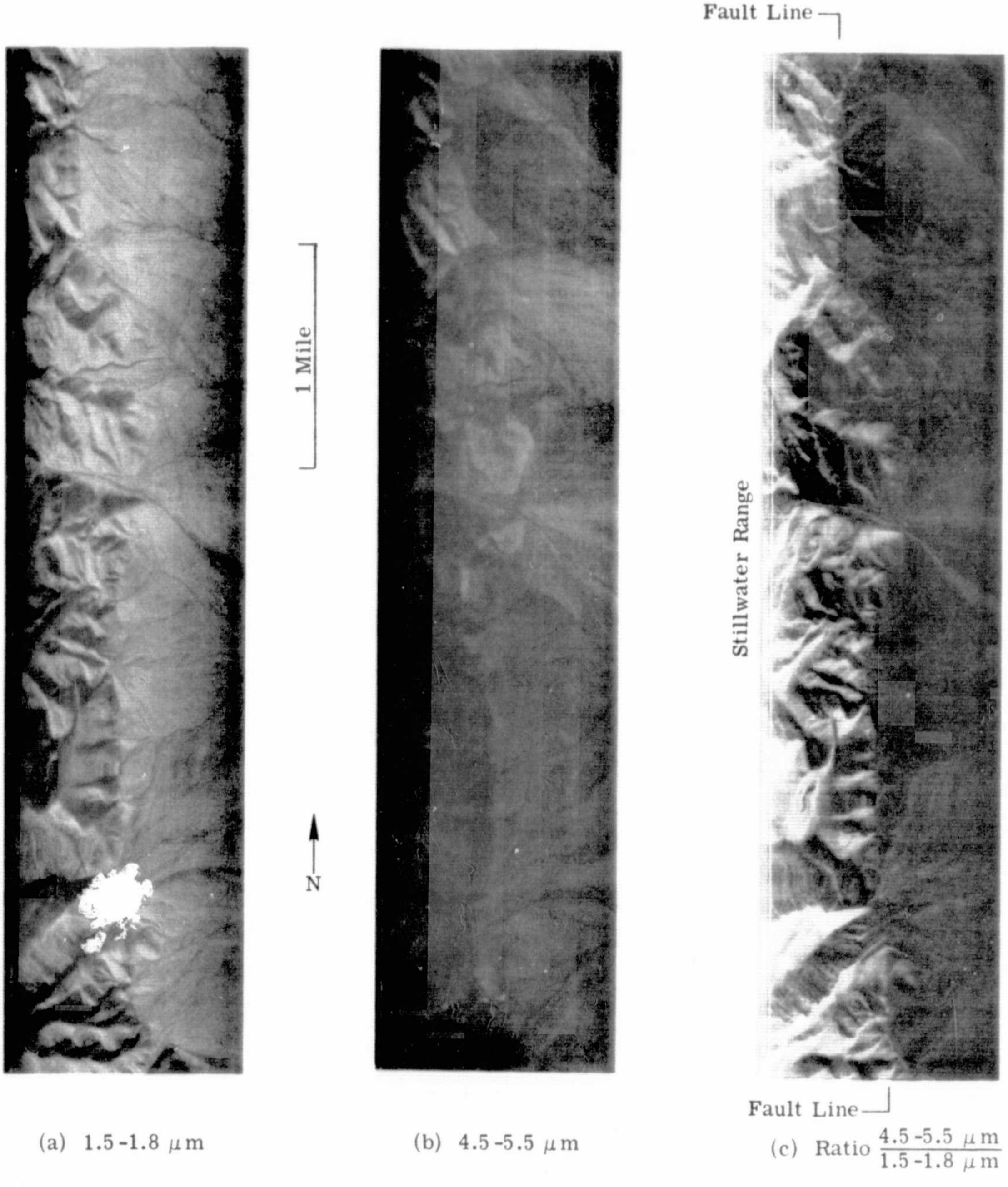
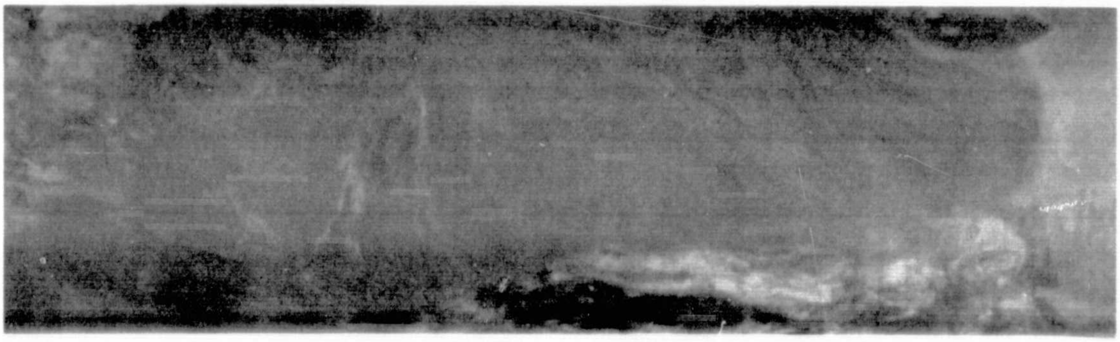
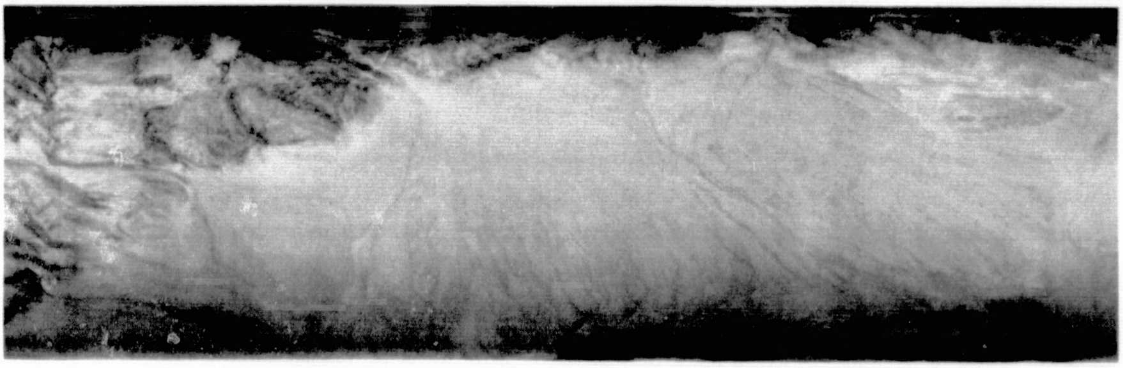


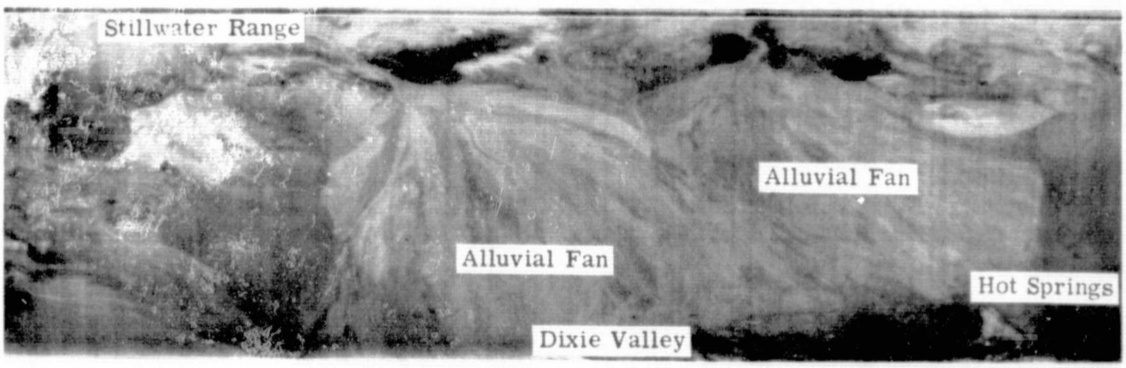
FIGURE 16. COMPARISON OF THREE MULTISPECTRAL IMAGES OF THE EASTERN BASE OF THE STILLWATER RANGE (DIXIE VALLEY), NEVADA, SHOWING THE LOCATION OF A FAULT ZONE



(a) 0.8-1.1 μm



(b) 1.5-1.8 μm

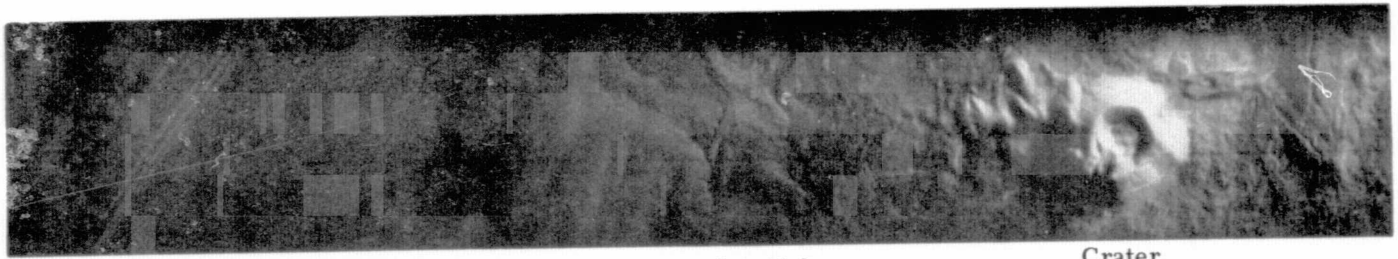


(c) Ratio $\frac{3.0\text{-}4.1\ \mu m}{1.5\text{-}1.8\ \mu m}$

1 Mile

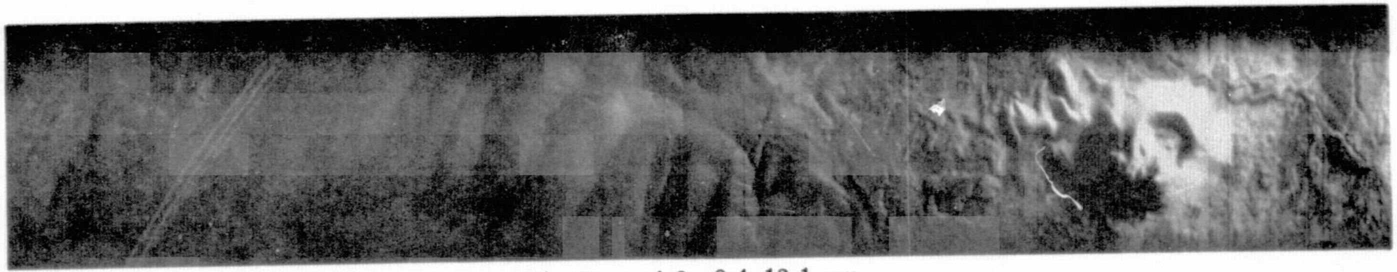
N

FIGURE 17. COMPARISON OF THREE INFRARED IMAGES OF THE ALLUVIAL FANS AT THE BASE OF THE STILLWATER RANGE, NEVADA. Data collected 25 May 1966 at 3000 ft (914 m) AGL.



Crater

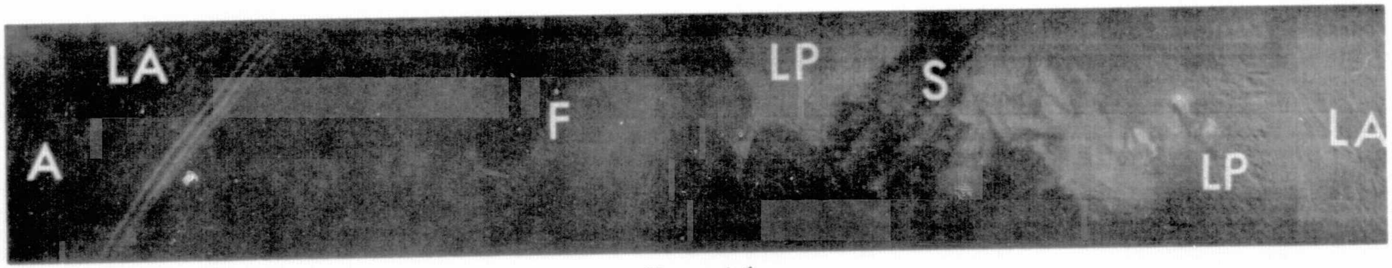
(a) Channel 1: 8.2-10.9 μm



(b) Channel 2: 9.4-12.1 μm

1 mile

N



(c) Ratio $\frac{\text{Channel 1}}{\text{Channel 2}} = R_{12}$

FIGURE 18. THERMAL INFRARED IMAGES OF THE PISGAH CRATER AREA, CALIFORNIA. Left to right: alluvium (A); partially covered basaltic lava (LA) of phase 2; highway, fanglomerate, and gravel (f); Pisgah pahoehoe basaltic lava (LP) of phase 3; windblown sand and silt (S); and Pisgah aa basaltic lava (LA) of phases 1 and 2. Data collected 30 October 1971 at 0840 hrs, 3000 ft (914 m) AGL.

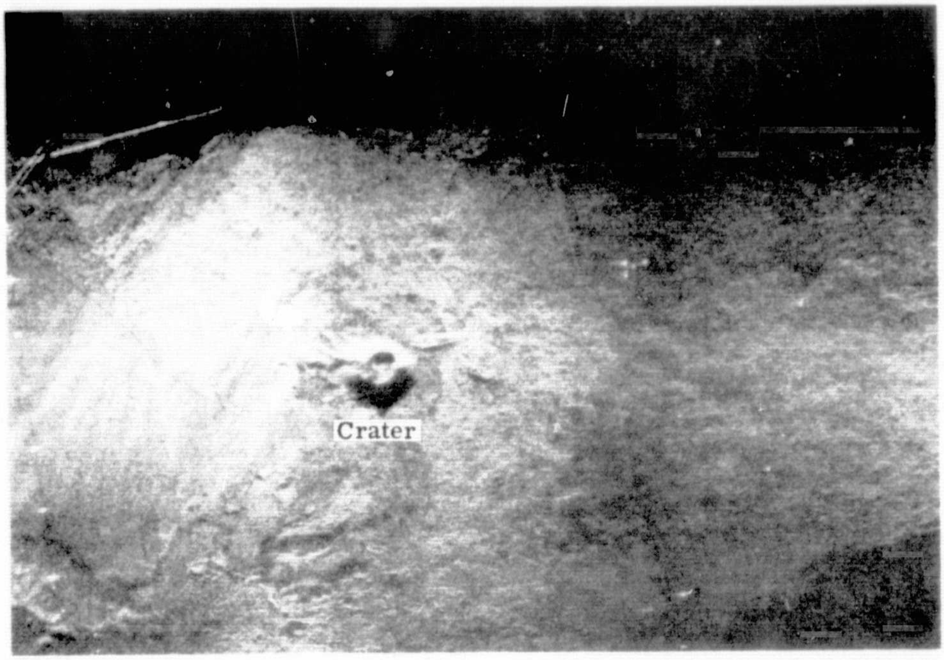
scanner data recorded in different bands of the same infrared spectral range. They primarily show terrain temperature differences related to the thermal properties of the materials and exposure to the sunlight. The data were collected several hours after sunrise and the southeast slopes of the crater have been heated by the sun while the shadowed northwestern slopes remain cooler. Also, the double lanes of the highway to the north appear warmer than the surrounding alluvium (dark toned on the image). Striking differences are seen in the ratio of these two images.

The ratio image, which has the effect of reducing image tone similarities between the two original images and enhancing differences, shows image patterns of light and dark related to the surface material and texture. For example, the annotated ratio image shows alluvium, fanglomerate, and gravel as dark and areas of basaltic lava as light-toned. Reasons for these differences are related, in part, to the emissivity differences of these materials in the two infrared bands recorded [28]. In particular, because of the emissivity differences of silicate versus non-silicate materials in the 8 to 10 μm range, in contrast to the 10 to 12 μm range where no such emissivity differences occur, the ratio of these two bands provides useful discrimination of geologic materials on the basis of composition and texture (particle size). Because this discrimination is based on the energy absorption of a vibrational mode of the silicon-oxygen band of the silicate molecule in the 8-10 μm waveband, this type of information is not available from other remote sensor systems.

Radar sensors, operating in the microwave portion of the electromagnetic spectrum, also provide unique geological information. ERIM's high resolution synthetic aperture radar collected X- and L-band imagery from the Pisgah Crater test site in 1971. The radar system has the advantage of obtaining wide-area coverage independent of an exterior illumination source (such as the sun for aerial photography). Also, since the reflected terrain signals are recorded at an oblique angle, they are much more dependent upon terrain roughness and object geometry than other types of remote sensor data.

Figure 19 shows the Pisgah Crater and surrounding lava flows with two different polarizations of the X-band data. In contrast to Figure 18 where the cone is illuminated from the east, the radar signals make the north side of the cone appear bright. In these images the rough-surfaced lava flows around the cone appear considerably lighter in tone, particularly in the lower (H-V) polarized image. Metal powerline poles appear as intense bright spots along the right side of the imagery.

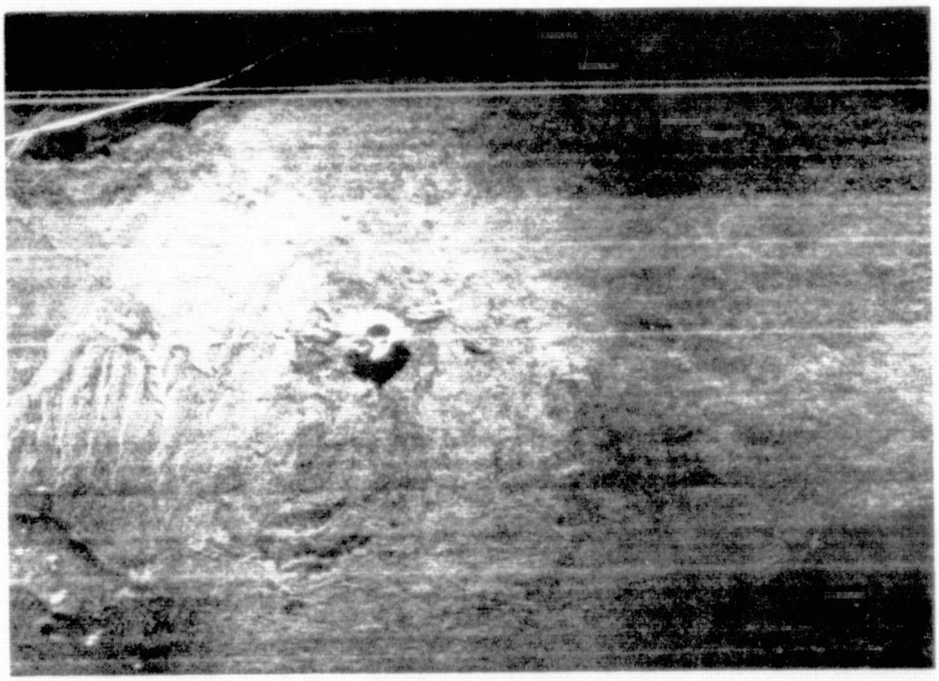
Figure 20 shows the 23-cm L-band images of the same Pisgah Crater area. Here the image detail is much coarser owing to the longer wavelengths used, but the alluvium remains darker than the rough-surface basaltic lava areas.



(a) X-Band 30' × 30' Horizontal-Horizontal

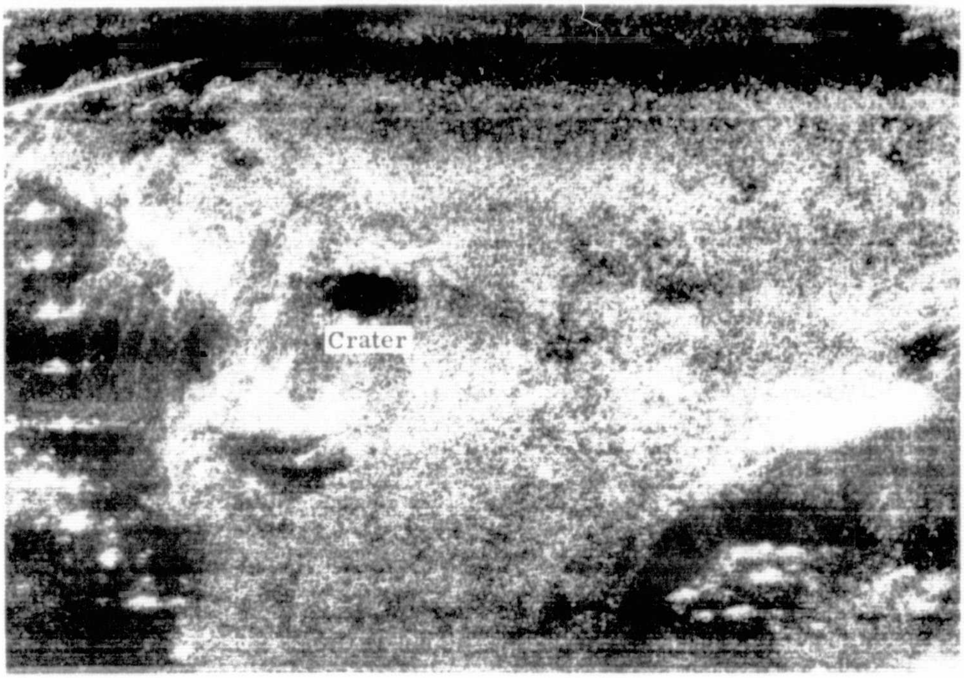
N

Direction of Flight →



(b) X-Band 30' × 30' Horizontal-Vertical

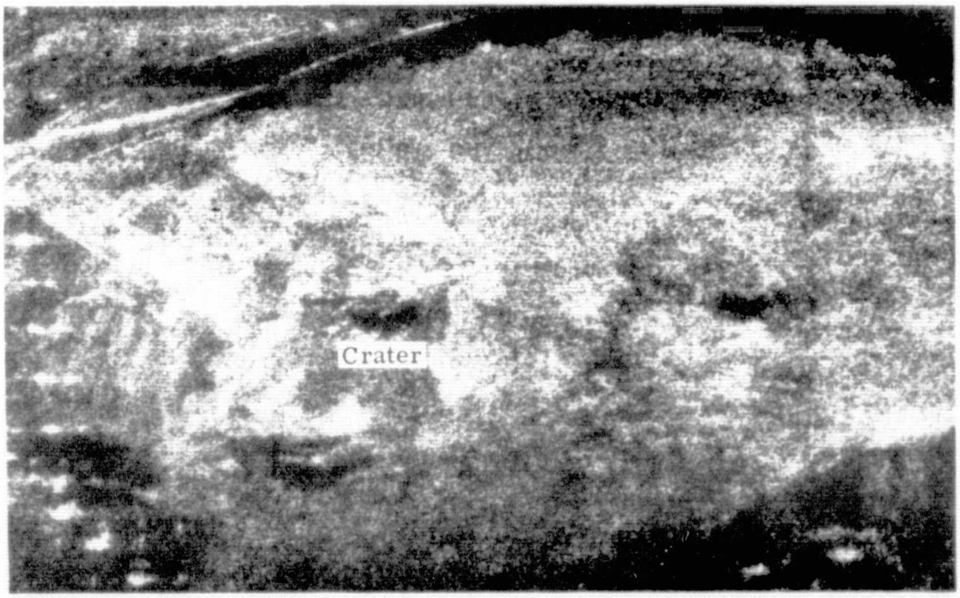
FIGURE 19. COMPARISON OF TWO POLARIZATIONS OF X-BAND IMAGERY OF PISGAH CRATER AREA, CALIFORNIA. Altitude: 5300 ft (1615 m) AGL; depression angle: near edge 46°, far edge 13°. Data collected in 1971.



(a) L-Band 30' × 30' Horizontal-Horizontal

N

Direction of Flight



(b) L-Band 30' × 30' Horizontal-Vertical

FIGURE 20. COMPARISON OF TWO L-BAND IMAGES OF THE PISGAH CRATER AREA, CALIFORNIA. Altitude: 5300 ft (1615 m) AGL; depression angle: near edge 46°, far edge 13°. Data collected in 1971.

2.4.5 EUTROPHICATION ASSESSMENT

2.4.5.1 Inland Lakes

The protection of the existing aesthetic and recreational values of inland lakes is a major contemporary water resource management problem. The development of an effective inland lakes management program for the protection of these resources will depend in part on the establishment of suitable data collection systems and data analysis procedures.

Eutrophication of surface waters is a natural process which is frequently accelerated by the activities of man. Numerous factors enter into the eutrophication process, including nutrient loading resulting from land-use practices and activities within the watershed, together with nutrient loading from natural sources. Hence, the development of effective preservation or improvement programs will require a data base which includes information regarding the existing trophic state of lakes together with land-use data for the watersheds in question. The latter is required for loading-function development and for the identification of land-use practices and activities which contribute to a degradation of surface waters. The information needed in large-scale eutrophication assessment and control programs is very extensive. Many of the requirements can be met through the application of remote sensing technology.

A review of the problem of eutrophication measurement indicates that over the years a wide range of parameters have been used to measure eutrophication and express trophic state [29, 30]. The number and variety of parameters used for this purpose reflects the fact that no single parameter can serve as the measure of trophic state. They also reflect the conceptual difficulty frequently associated with the term, which has been used to describe either the productivity status and/or the nutrient status of a lake. In general, however, an attempt is normally made to measure, directly or indirectly, the major manifestation of eutrophication which, of course, is an increase in the concentration of phytoplankton and higher plants and a corresponding change in the optical properties of the water mass.

Chlorophyll "a" suspended solids and transparency are measurable by remote-sensing techniques and could serve as the basic parameters for eutrophication assessment. In the case of eutrophic bodies of water, the above measurements can be supplemented by measurement of the distribution of littoral and/or floating vegetation as well as by documentation of algal blooms. It should be noted that all of the above parameters and manifestations are widely used as indicators of trophic state.

ERIM, in cooperation with a number of local agencies in Genesee County, Michigan, recently completed a program designed to introduce remote sensing technology into local environmental planning and public policy formulation processes in an inland lakes area [31]. One phase of this program involved the environmental assessment of selected inland lakes and their adjacent watersheds. Processing techniques were developed to extract information from multispectral scanner data regarding water transparency and chlorophyll content. Results of theoretical and experimental studies indicate that: (1) the addition of suspended solids to water decreases its transparency, and also causes an increase in reflectance which is more pronounced in the red than in the green region of the spectrum (Figure 21); and (2) the addition of cholorphyll "a" to water causes a relative decrease in reflectance in the blue region as compared to the green and red regions of the spectrum. In general terms, ratios of observed reflectances in the appropriate wavelength bands may be used as indicators of water transparency and chlorophyll content, although the relationships are nonlinear.

Figure 22 shows two analog processed ratio images in which the tones represent the values of reflectance ratios which have been found to correlate closely with water transparency and surface chlorophyll "a" content, respectively. Quantitative results were obtained using digital processing techniques. (An example of digital processing results is included in Section 2.4.7, Coastal Oceanography.)

Concurrent measurements of transparency with a Secchi disc and laboratory measurements of chlorophyll "a" content have confirmed their correlation within the range of 0.7 to 6.0 meters of Secchi disc transparency and 0.1 to 50 mg/m^3 of chlorophyll "a" concentration.

As part of the above cited inland lakes study, the concept of a remote sensing trophic state index was examined and demonstrated [31, 32]. The terms included in the index were:

$$TI = k_1 \frac{1}{T_{RS}} + k_2 CH_{RS} + k_3 V_{RS} + k_4 T_{ratio} + k_5 \Delta CH + k_6$$

where

TI = trophic index

T_{RS} = transparency (standardized value)

CH_{RS} = chlorophyll (standardized value)

V_{RS} = aquatic vegetation (standardized value)

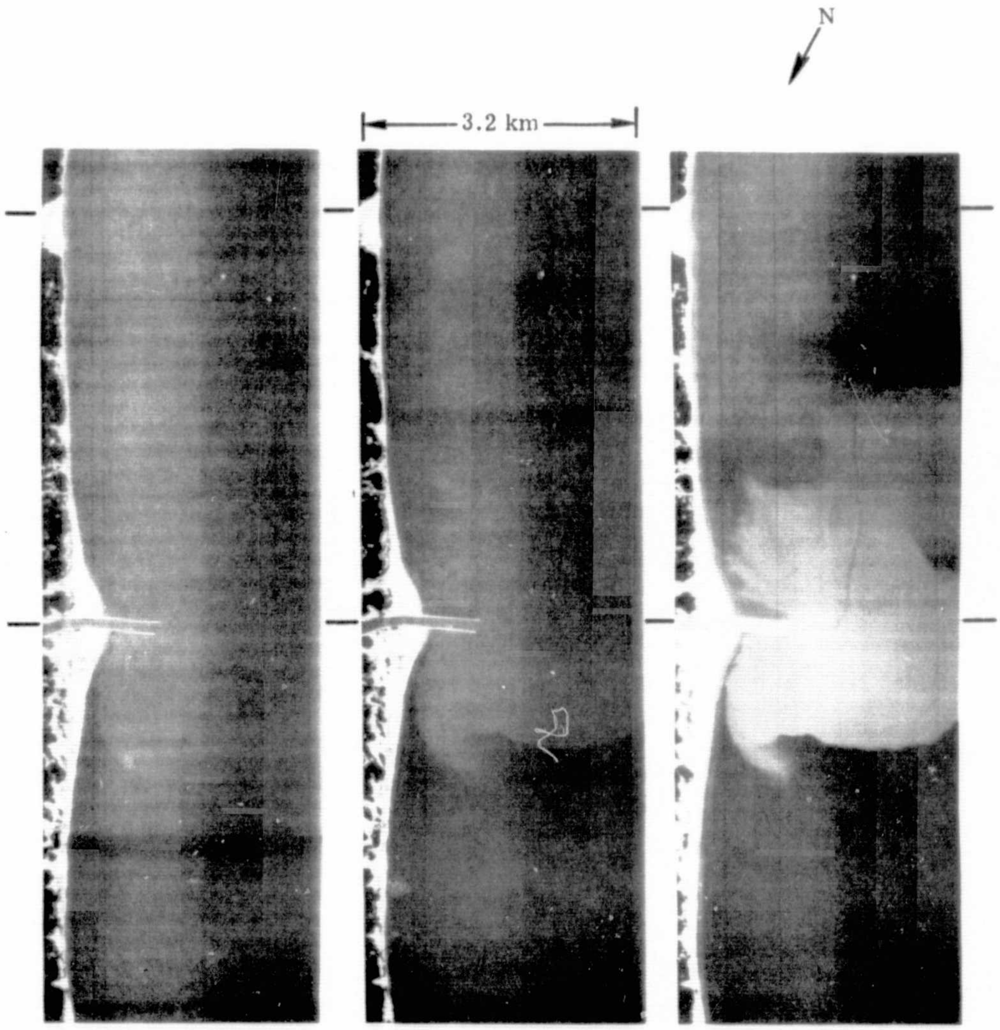
T_{ratio} = transparency ratio (standardized value)

ΔCH = chlorophyll increase (standardized value)

k_1, k_2, k_3, k_4, k_5 = weighting factors

The above trophic index is a dimensionless number which includes weighting factors determined through principal component analysis. The standardized values to be used in the equation are determined for each parameter by subtracting the mean value and dividing by the standard deviation in each case. The last constant in the equation is introduced for scaling purposes.

The index was designed for lakes which exhibit significant seasonal changes. Ideally, the first three terms (T_{RS}, CH_{RS}, V_{RS}) would represent the worst conditions encountered during

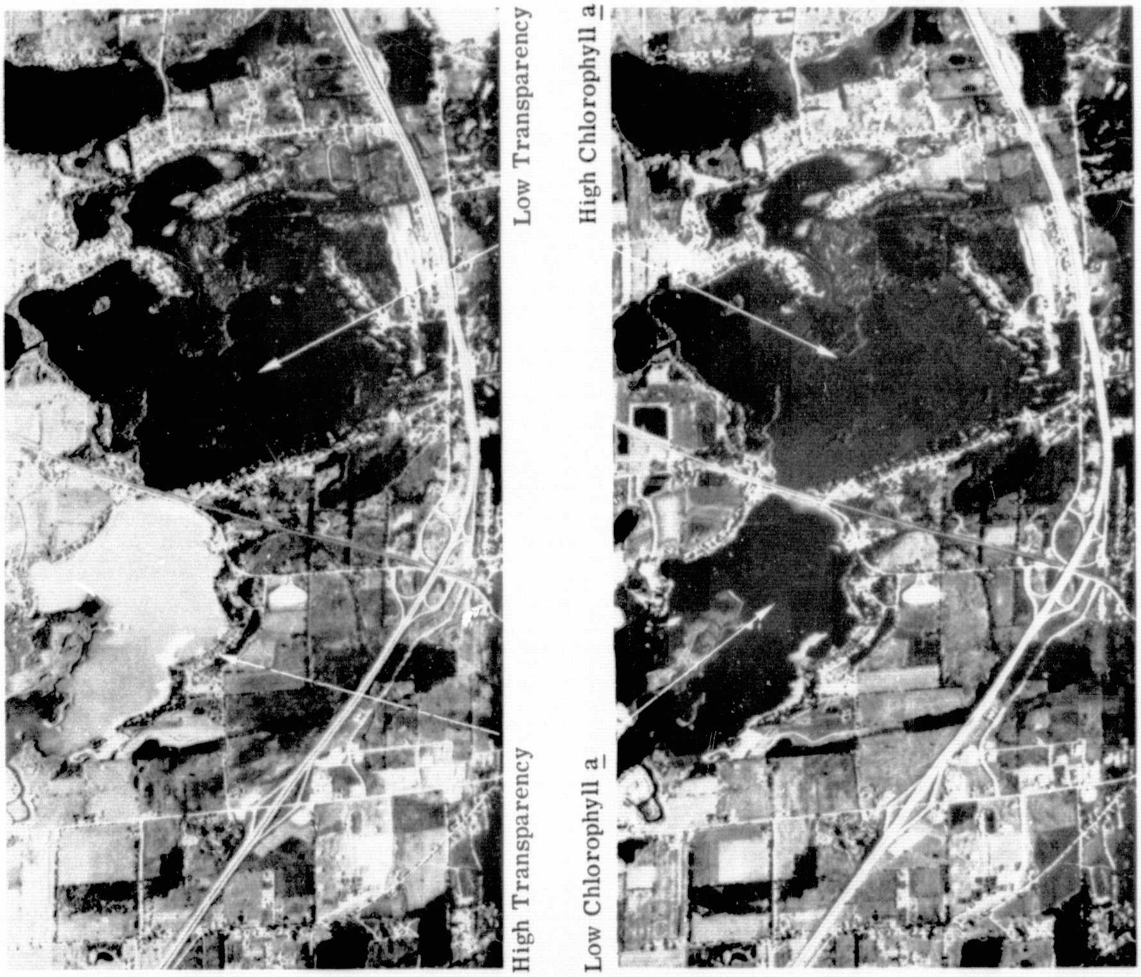


(a) 0.41-0.48 μm
Blue

(b) 0.50-0.54 μm
Green

(c) 0.62-0.70 μm
Red

FIGURE 21. SUSPENDED SOLIDS. Eastern shoreline of Lake Michigan; altitude 5000 ft (1524 m) AGL.



(a) Secchi Disk Transparency

N

(b) Chlorophyll a

FIGURE 22. ANALOG PROCESSED RATIO IMAGERY, SILVER LAKE-LAKE PONEMAH, GENESEE COUNTY, MICHIGAN. 22 August 1973, 1017 hours, 5000 ft (1524 m) AGL.

a season; the next two (T_{ratio}, ΔCH) are included in order to measure the shift between pre-season and peak conditions. Clearly, in the case of an oligotrophic lake any change in the latter parameters would be modest in contrast to the large shifts which occur in eutrophic lakes. A color term could be added which would facilitate normalization of a data set which included both clear and colored lakes.

2.4.5.2 Great Lakes

Another indication of the trophic state of a lake is the extent of aquatic vegetation. In the case of Lake Ontario, the inflow of nutrient rich waters from tributary sources, together with nutrient loading from major population centers around the lake, is sufficient to maintain a relatively high level of productivity. This is evidenced in part by an extensive growth and development of benthic algae Cladophora.

Cladophora consists of long strands which are normally attached to a hard bottom in nearshore areas. However, at one point in the life cycle, the algae become detached through wave and wind action and are deposited on the beach. From the viewpoint of the shoreline property owner, the subsequent decomposition of large masses of Cladophora produces highly objectionable conditions which detract from the aesthetic and recreational values of the nearshore zone.

Any attempt to delineate the distribution (and estimate the standing crop) of benthic algae or aquatic macrophytes must face the issue that conventional methods of data acquisition are totally inadequate, particularly when dealing with a large environmental system. The utilization of some form of remote-sensing technology is clearly indicated for this purpose.

In a project under the sponsorship of the U.S. Environmental Protection Agency, multispectral remote-sensing data were collected for this purpose during the summer of 1972 along the U.S. shoreline of Lake Ontario.

In this effort, remote sensing technology was developed and used for the following purposes:

(1) to delineate the distribution of Cladophora (benthic algae) along the U.S. shoreline,

(2) to provide an estimate of Cladophora standing crop (biomass) by coupling remote-sensing data with ground-truth information.

To accomplish these goals, a processing technique involving the ratio of two spectral channels was developed for discriminating between Cladophora and bare substrate, usually sand, under a variable depth of water ranging from 0 to 5 meters. A single-channel technique was found to be inadequate because in any given channel the signal observed over Cladophora in shallow water is equal to the signal over sand in deeper water. Using the ratio of the signals in two channels having the same water attenuation resulted in a depth-invariant index of bottom type.

Both analog and digital processing was used. In the analog imagery (Figure 23a) light tones represent sand and dark represent Cladophora. In the digital product (Figure 23b) a light symbol represents sand and a dark symbol represents Cladophora. Land areas were edited out using a near-infrared channel, and an automatic count of light and dark symbols was used to estimate the total area covered by Cladophora.

The results show an extensive growth and development of Cladophora in the study area. Approximately 66% of the nearshore zone (to the 5-meter depth contour) in the western portion of the lake and 79% in the eastern portion was found to be covered by Cladophora [33].

The results form part of the environmental data base for Lake Ontario and are published in the EPA Ecological Research Series. Data from this report have also been incorporated in a technical report to the International Joint Commission [34].

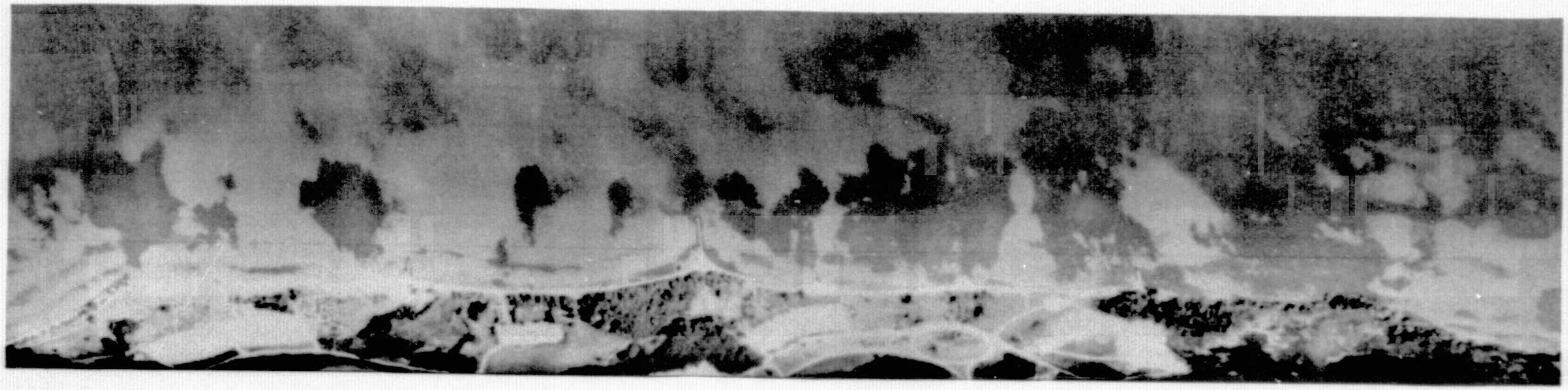
2.4.6 POWER PLANT DISCHARGES AND THERMAL CHARACTERISTICS OF SURFACE WATERS

Temperature is an important environmental parameter which has a bearing on all chemical, physical, and biological processes. Therefore, documentation of existing thermal conditions in a body of water is normally a prerequisite for (1) assessing the impact of thermal discharges, (2) water quality modelling, and (3) planning municipal, industrial, and recreational uses of surface waters. Once thermal standards have been established, information regarding temperature distribution must be acquired on a routine basis to determine compliance with established standards.

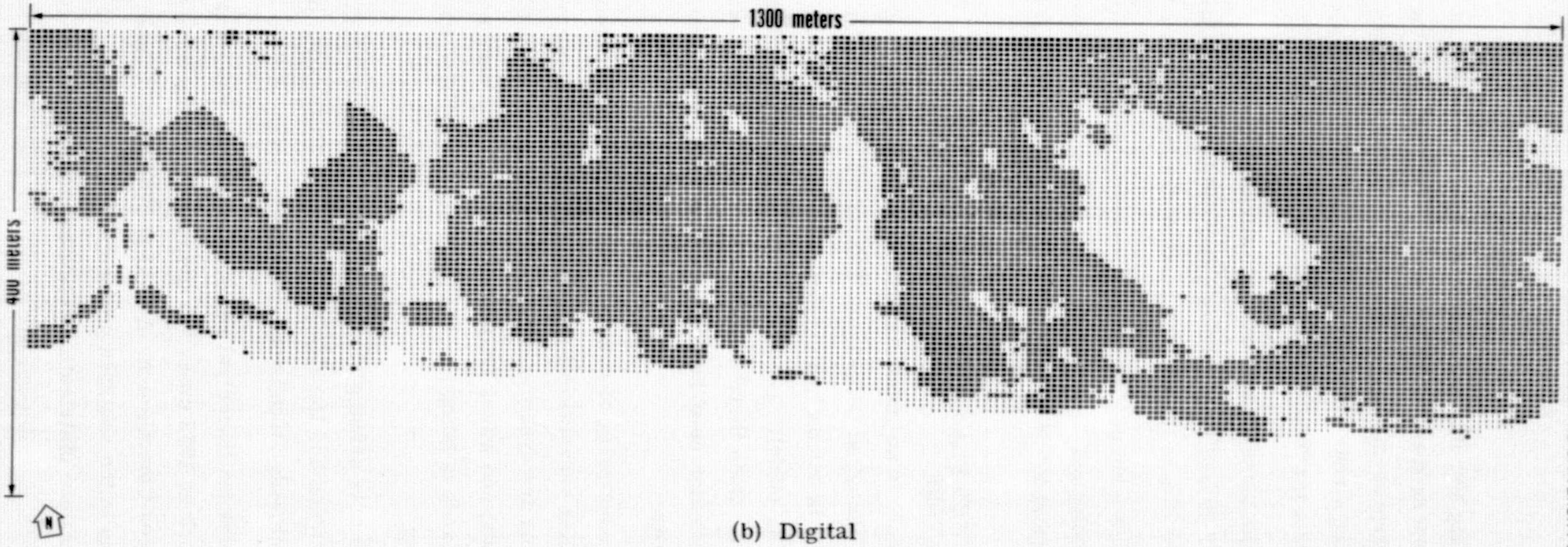
Thermal monitoring of power plant discharges is frequently an extremely difficult task to accomplish using conventional methods. Normally the discharge plumes are large in terms of areal extent and are dynamic in nature. Also, environmental conditions such as air temperature, high winds, and waves frequently make surface monitoring impractical. As a consequence, increased reliance is being placed on the use of airborne thermal-infrared techniques for thermal monitoring.

Several remote sensing studies of power plant discharges have been conducted for both regulatory agencies and the electric power industry, dating back to 1967. Two case studies are cited in the following discussion.

An extensive multispectral remote sensing program was conducted during the period August 1972 to June 1973 under the sponsorship of the Michigan Department of Natural Resources, Water Resources Commission. A total of 275 miles of multispectral data was collected at selected locations in the southern peninsula of Michigan during three seasons of the year. The surface temperature distribution resulting from the discharge of heated condenser cooling water

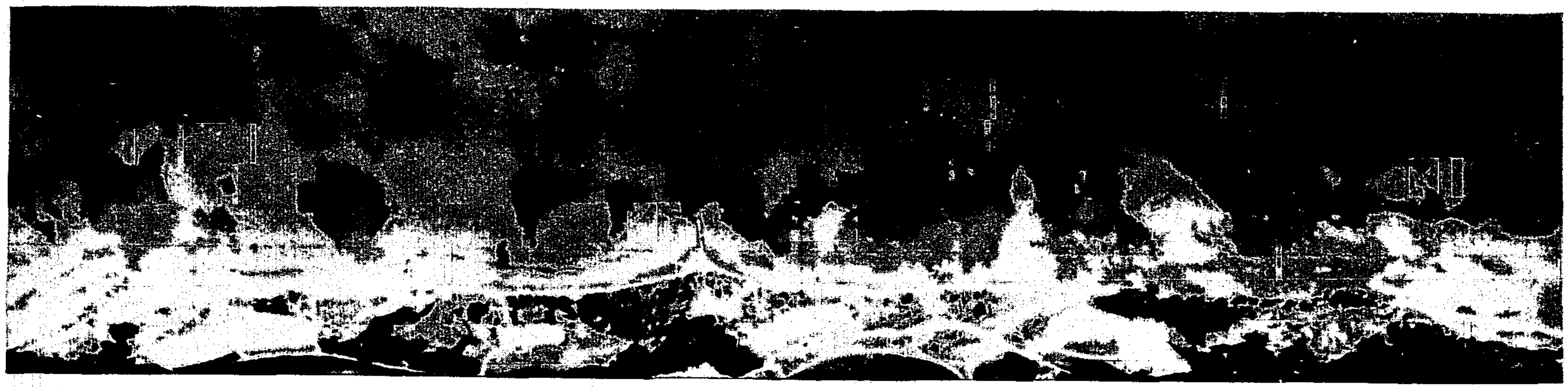


(a) Analog

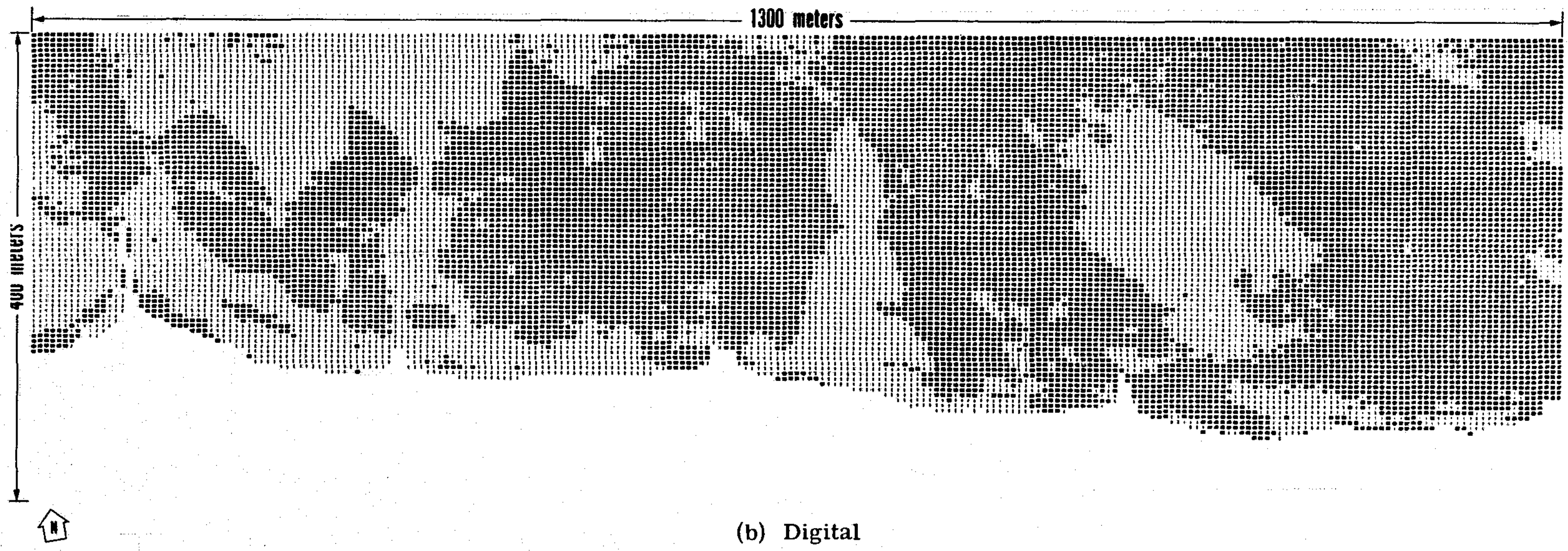


(b) Digital

FIGURE 23. RATIO IMAGERY, CLADOPHORA DISTRIBUTION, HAMLIN BEACH STATE PARK, NEW YORK. 20 June 1972.



(a) Analog



(b) Digital

FIGURE 23. RATIO IMAGERY, CLADOPHORA DISTRIBUTION, HAMLIN BEACH STATE PARK, NEW YORK. 20 June 1972.

into the public waters of the State was calculated and displayed using digital processing techniques. The basic presentation format consisted of black and white digital maps, which displayed scene temperatures at $1^{o}F$ levels, together with tables indicating the area for each temperature interval of interest. In addition, to these basic digital maps, data delivered included color-infrared photographs of each power plant, black and white thermal imagery of each scene, and on a selected basis, color digital thermal maps.

The data were used by the Michigan Water Resources Commission in determining the National Pollutant Discharge Elimination System (NPDES) permit limitations for power plants at the locations included in the study [35].

Similar studies have been conducted for the electric power industry. Quantitative data have been displayed in color-coded digital format, analog-processed thermal slices, and color-coded analog-processed color composites. Analyses of the thermal distribution resulting from cooling water discharges, natural thermal development in surface waters, and mixing patterns under a variety of environmental conditions have been examined.

Figure 24 presents a series of thermal-infrared images (9.3-11.7 μm), which show the thermal loading from a power plant and river discharge into the nearshore zone of Lake Michigan and the formation of the thermal bar. The thermal bar is characterized by the sharp thermal discontinuity in the 30 April scene. The light tones in the imagery represent warmer water. The illustration is taken from a report prepared for Consumers Power Co., Indiana and Michigan Electric Co., and Northern Indiana Public Service Co. [36].

An important feature in Figure 24 is the coastal entrapment of the power plant effluent and river discharge, and the transport of the discharge along the shore. The large-scale current pattern along the eastern shore of Lake Michigan is characterized by a coastal jet structure; therefore, discharges at or near the shore will normally move along or parallel to the shore, except at stagnation points. The currents are "bistable" and the direction may be either north or south. From a water-quality management standpoint, the above features have numerous implications. Decisions regarding plant siting, location of sewer outfalls, location of water intakes, recreational development, etc., must take into consideration naturally occurring physical processes as illustrated by the above example.

2.4.7 COASTAL OCEANOGRAPHY

The coastal waters adjacent to the New York Metropolitan Region are subjected to extreme cultural pressures. The area is the repository for substantial quantities of sewage sludge, industrial acid-iron waste, and other waste substances [37].

Multispectral remote sensing data were collected at two points in the tidal cycle in the New York Bight on 7 April 1973, under the sponsorship of the National Oceanic and Atmospheric

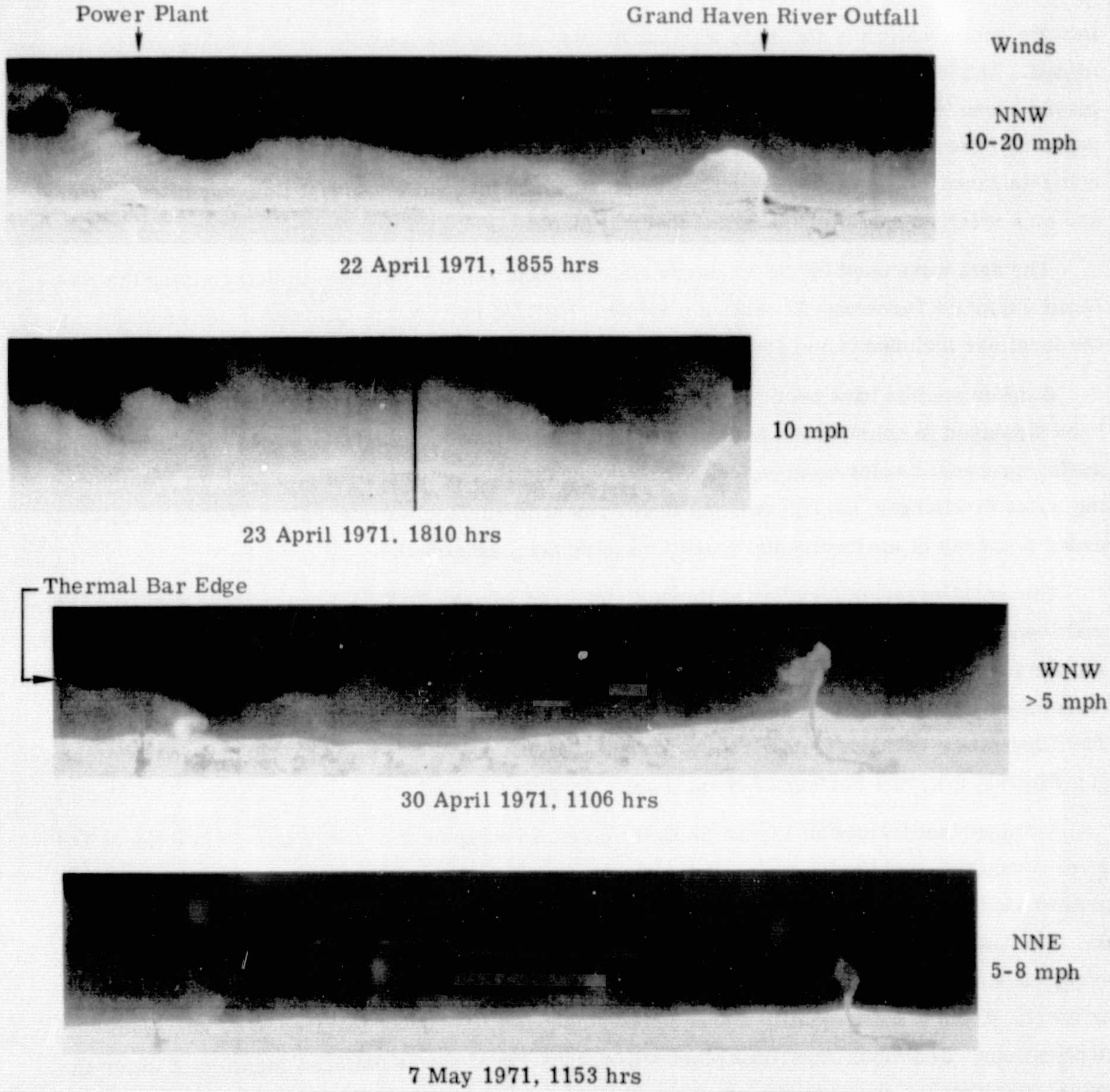


FIGURE 24. FORMATION AND MOVEMENT OF THERMAL BAR SHOWING COASTAL ENTRAPMENT OF DISCHARGES. Area: 14.5 × 2.7 mi (23.3 × 4.4 km).

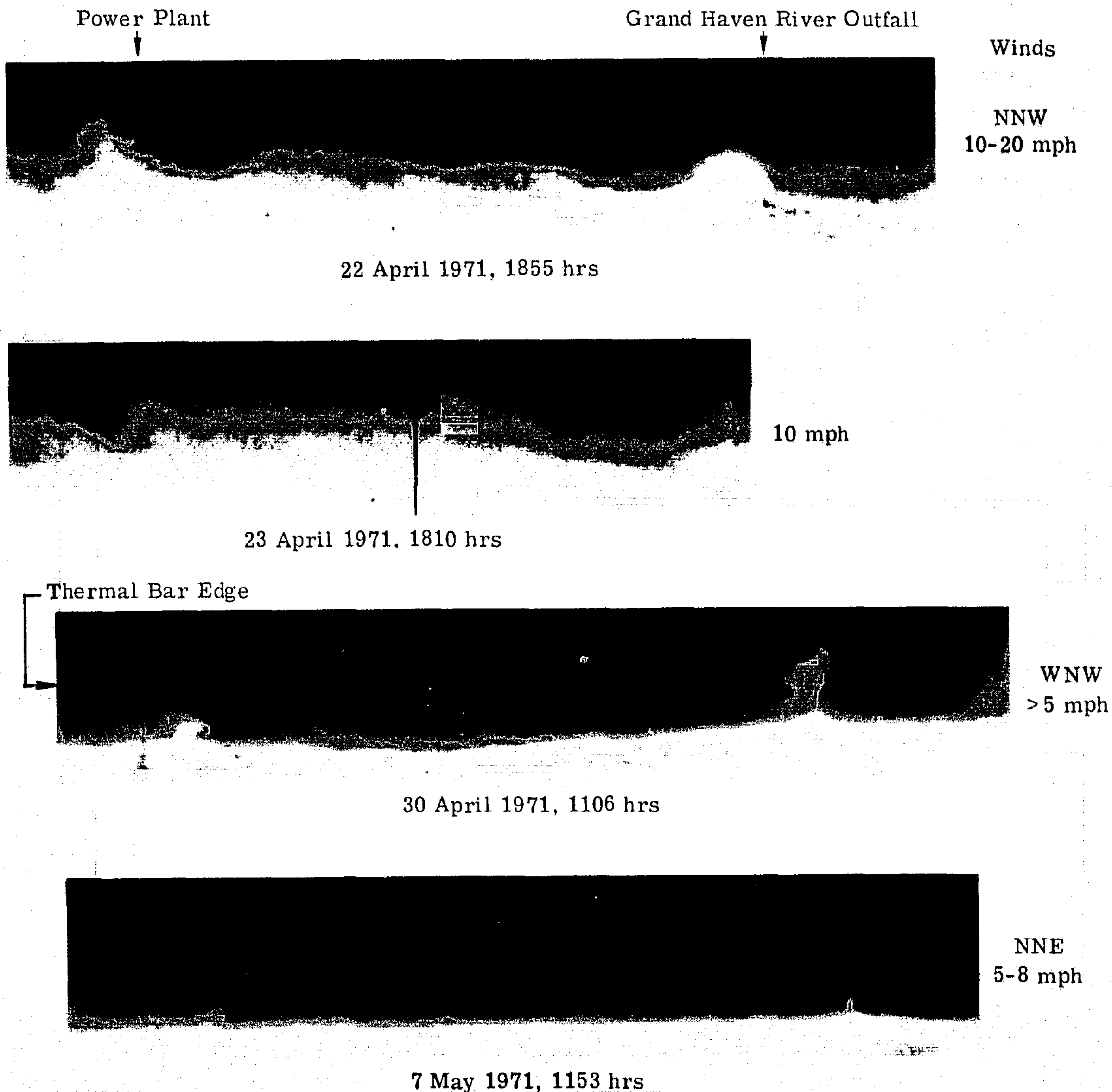


FIGURE 24. FORMATION AND MOVEMENT OF THERMAL BAR SHOWING COASTAL ENTRAPMENT OF DISCHARGES. Area: 14.5 × 2.7 mi (23.3 × 4.4 km).

Administration. Data were processed to show the movement of water masses as evidenced by sea surface temperature, dye tracer, and turbidity patterns. Additionally, digital processing was performed to display surface chlorophyll concentrations and transparency. Ocean dumping of waste in the Bight was also documented. The program was conducted in support of one phase of the NOAA Marine Ecosystems Analysis (MESA) program in the Bight.

Waste fields created by barge dumping of acid-iron waste were clearly in evidence in the study area. Acid-iron in the process of being discharged, recently dumped waste, as well as relatively old waste suspensions were detected. Figure 25 shows a typical acid-iron dumping operation in progress. The waste solution changes in appearance from a green-yellow color to orange as the material undergoes oxidation from the ferrous to the ferric state. Due to the low solubility of iron at the pH of seawater, precipitates are formed. The ferric compounds produced tend to remain in suspension for considerable periods of time. The oxidized waste field is yellow or orange in color.

The ability to measure small temperature differences can frequently be utilized in the analysis of a number of oceanographic problems including analysis of circulation dynamics. Shown in Figure 26 is a thermal map (9.3-11.7 μm) of the study area during an outgoing tide. The highly complex surface circulation in the lower bay and adjacent areas is clearly depicted. The sharp thermal discontinuities provide information about flow direction, mixing, and water mass convergence. Surface temperature distribution was delineated through digital processing of the scanner data collected in the 9.3-11.7 μm spectral band.

The problem of ocean color analysis is extremely complex due to the fact that the aquatic environment is a complicated heterogeneous system in terms of its chemistry and biology. As a consequence no simple, straightforward, universal solutions to the problem of chlorophyll and transparency analysis are possible. All attempts to measure these parameters through remote sensing have involved empirical or semi-empirical methods.

The techniques adopted in this program are based on the anticipated changes in volume reflectance due to the presence of chlorophyll and non-chlorophyll-bearing particulates [32]. Spectral bands in the blue, green, and red regions of the spectrum were utilized. The results of data processing for surface chlorophyll-a are shown in Figure 27. The ground-truth data (and times of collection) are indicated next to the black squares in the figure. The results show a range in surface chlorophyll "a" from 1.1 to 35 mg/m^2.

The use of remote sensing, from both aircraft and satellite, is demonstrated in studies of the highly complex and dynamic estuarine and coastal environment represented by the New York Bight and adjacent bay areas. Interpretation of analysis of data collected by conventional point-sampling techniques is likely to be extremely difficult without reference to remote sensing data.

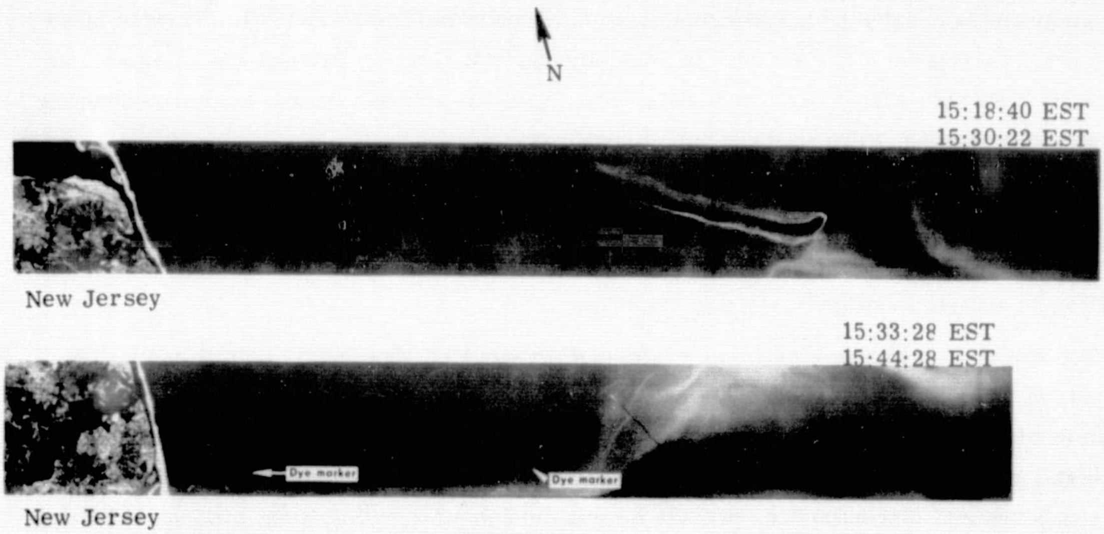


FIGURE 25. BARGE DUMPING OF WASTE, NEW YORK BIGHT. 7 April 1973, afternoon data, 10,000 ft (3048 m) AGL.

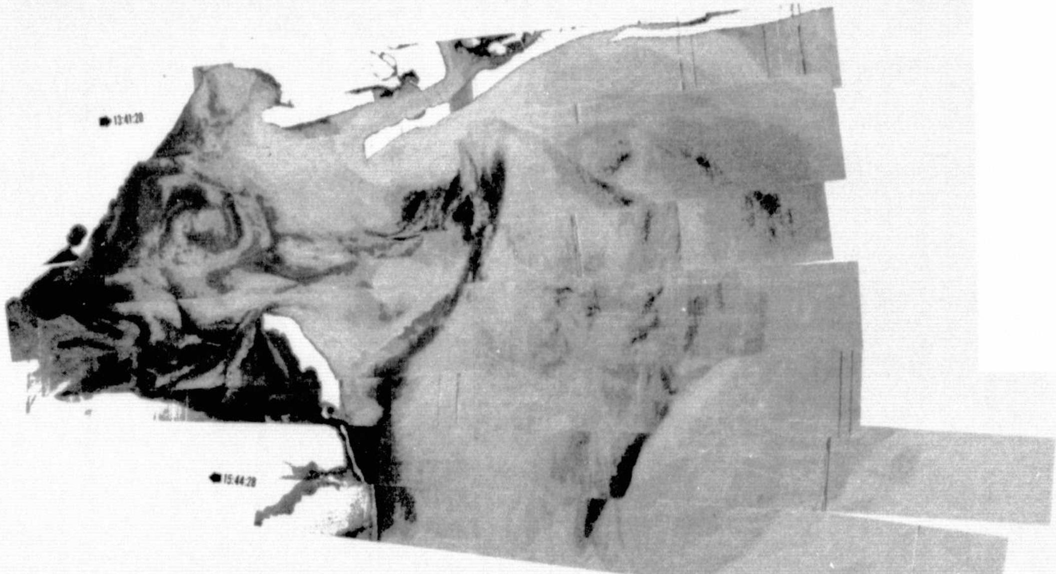


FIGURE 26. DIGITAL TEMPERATURE MAP, NEW YORK BIGHT. 7 April 1973, afternoon data.

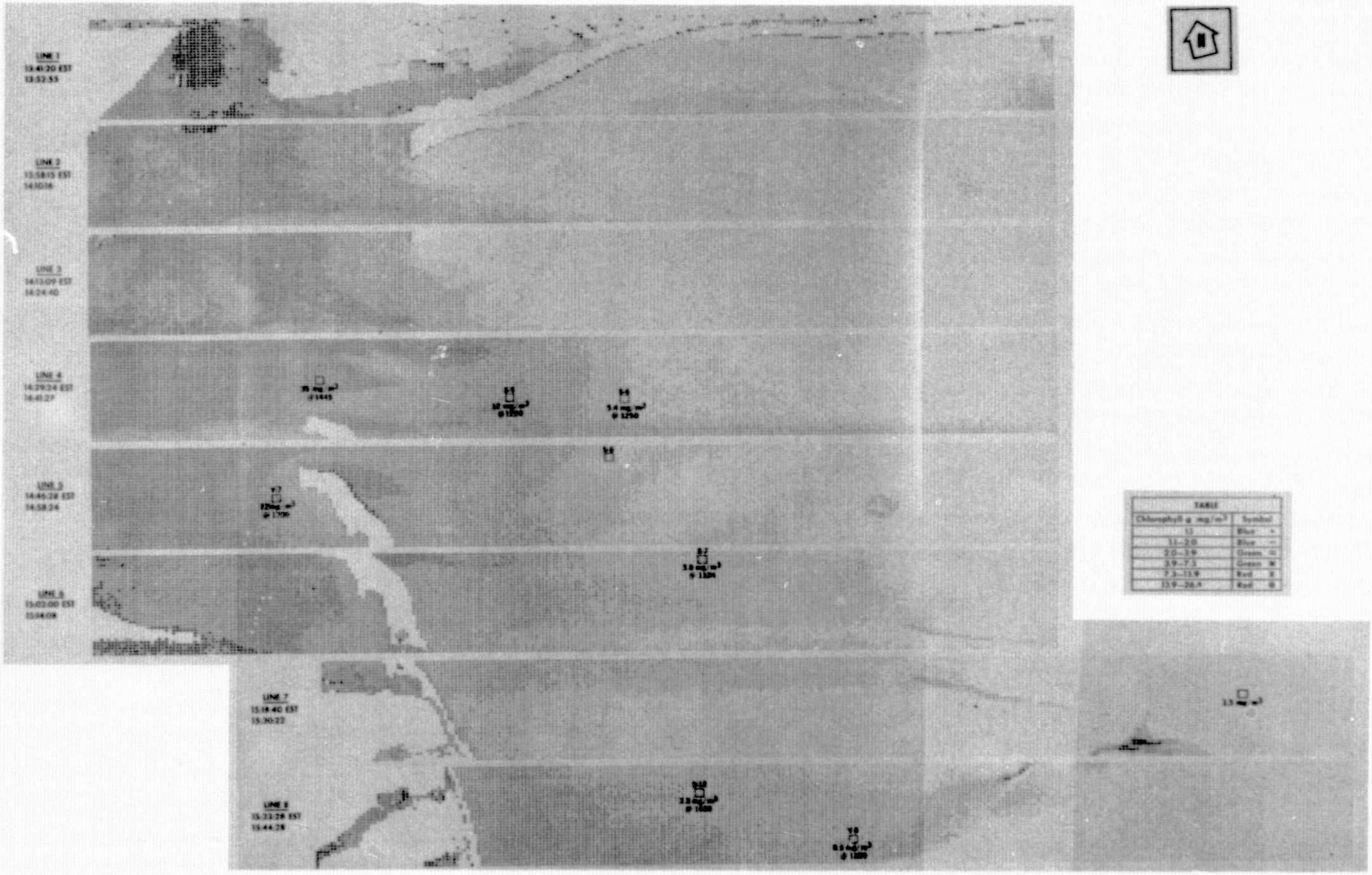


FIGURE 27. SURFACE CHLOROPHYLL DISTRIBUTION, NEW YORK BIGHT. 7 April 1973.

The optimum solution is to exploit the capabilities of remote sensing technology and combine the information so derived with data acquired by conventional point-sampling methods. The results of the remote sensing program in the New York Bight are presented in ERIM Report No. 109300-5-F [38].

2.4.8 WETLANDS MAPPING

Wetlands are defined generally as those lowlands covered with shallow and sometimes temporary or intermittent water [39]. Included in this broad grouping are all those areas commonly known as swamps, bogs, marshes, potholes, and wet meadows. Most wetlands can be drained or filled, creating land more suitable for human activities. This has resulted in the past in public opinion which regarded most natural wetlands as wastelands, fit only for "improvement," so that they might be put into use supporting agricultural, industrial, or residential expansion.

Only recently has a public awareness of the ecological value of wetlands become widespread. The ecological functions wetlands have been found to serve are convincing proof of the importance of the need for their preservation. Among these important functions are the following:

(1) habitat for fish and wildlife
(2) water quality maintenance
(3) flood and erosion control
(4) ground water recharge
(5) buffer zones along shorelines of large lakes.

Wetlands have social values too, providing open space for recreation, education and research. In many areas wetlands can also be used to grow cash crops, such as marsh hay, wild rice, and blueberries and cranberries [40].

Before a plan can be intelligently formulated for the preservation of wetlands, however, it is essential to have at hand the information provided by a detailed inventory which describes their composition, location, distribution and condition. Unfortunately, traditional field procedures for wetlands mapping are expensive, time-consuming, and often of limited accuracy. A major cause of all this difficulty is the poor trafficability of most wetlands, and the constraints that this imposes on conventional surveying techniques. In addition, the vegetation communities of many types of wetlands are extremely dynamic and, in order to maintain an up-to-date data base for management decision-making, they must be remapped frequently.

Remote sensing techniques have spatial, spectral, and temporal advantages over ground-based mapping methods that make their application to wetlands mapping a good one. Principal among these is the spatial overview of the environment provided by the aerial perspective.

Spectrally, when a multispectral scanner system is used, several wavelength regions(e.g., ultraviolet and the infrared portion of the spectrum beyond 1 micron and thermal radiation) provide new ways to characterize vegetation units and energy exchange processes. From a temporal standpoint, data can be collected rapidly and often, and the permanent record that results can be used independently by other investigators, permitting them to make their own interpretations of the data, perhaps for entirely different purposes from those for which they were originally collected.

The following project synopsis illustrates the potential of an airborne multispectral scanner system for aiding in wetlands management by showing how the critical mapping task can be done far more quickly using computer data-processing techniques. The mapping of the area under consideration was performed for several reasons: (1) to document existing conditions; (2) to correlate vegetation cover conditions with water level manipulation practices; and (3) to assess the area's current and potential capability for use by waterfowl.

Pointe Mouillee State Game Area is located at the mouth of the Huron River, on the Lake Erie shoreline just south of Detroit (Figure 28). Centrally situated along the Mississippi Flyway, the marsh is both an important feeding and resting area for waterfowl during migration and one of the few remaining public waterfowl hunting areas in Southeastern Michigan.

Unfortunately, the viability of this game area is being seriously threatened by both natural influences and man's activities. Lately the area's usefulness has been particularly impaired through gradual deterioration of the estuary's marshland, and more recently, because of additional erosion caused by severe flooding due to spring and fall storms coupled with high water levels in Lake Erie (Figure 29).

Since most birds use the marsh only as a migration stopping place, management of the area focuses on maintaining a large crop of quality waterfowl foods. Most of the active management is concentrated on a core refuge area of 369 acres. The management strategy employed at Pointe Mouillee is typical of many midwestern marshes. Located along two major waterfowl migration routes, the marsh serves as a major resting and feeding stopover point. For this reason, management emphasis is placed on supplying large amounts of waterfowl food, with enough cover not only to attract and hold a maximum number of ducks during the fall hunting season, but also to provide for the needs of the birds during the spring migration.

The problem is really two-fold. First, to largely exclude cattails, which are the dominant cover type in the rest of the marsh, from the refuge area, and second, to favor the establishment of emergent plant species more valuable as food, such as smartweed, pigweed and burweed [41, 42]. This is accomplished basically through manipulation of the water level within the diked refuge area. Pumps are used to drain the area in late spring so that the food species can

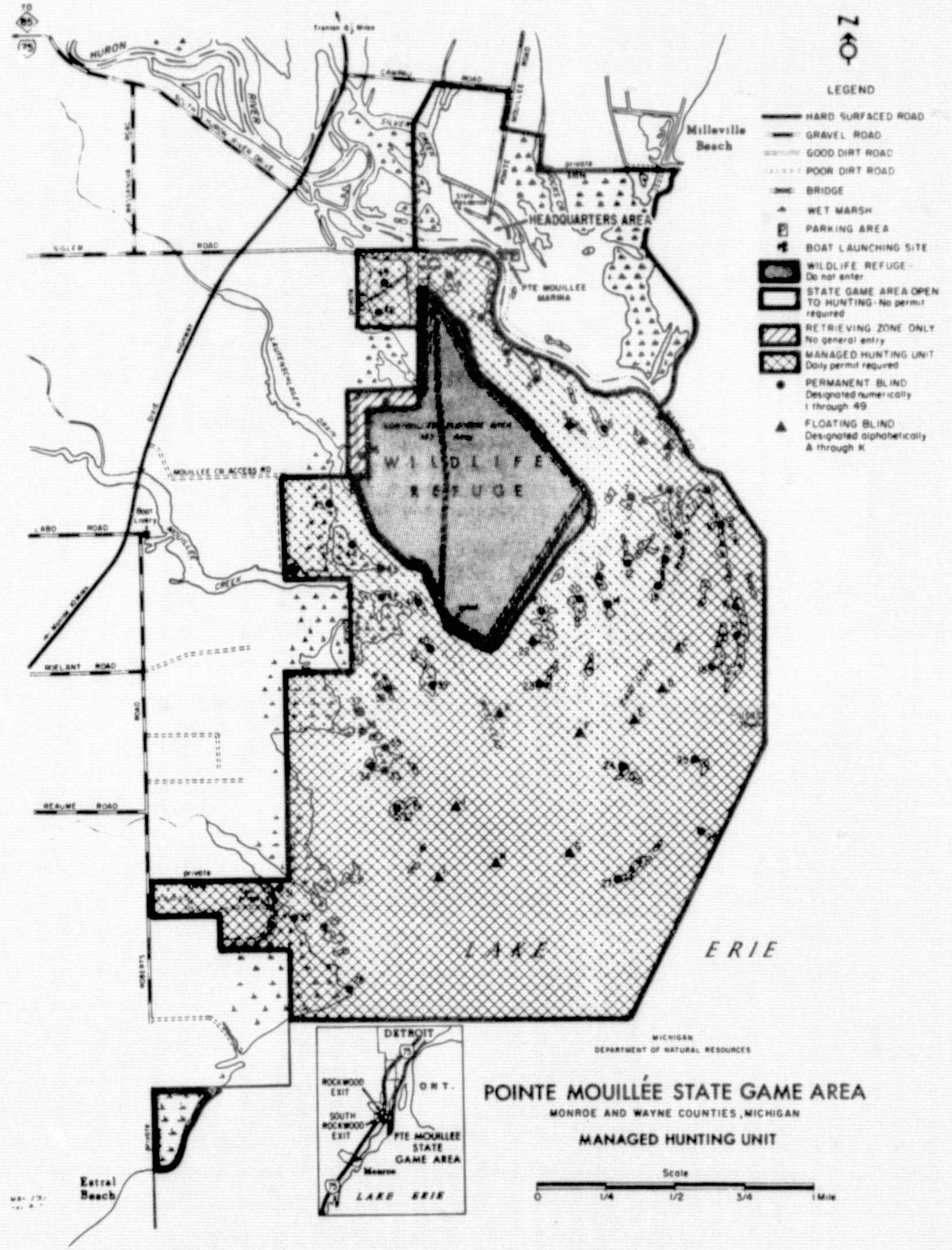
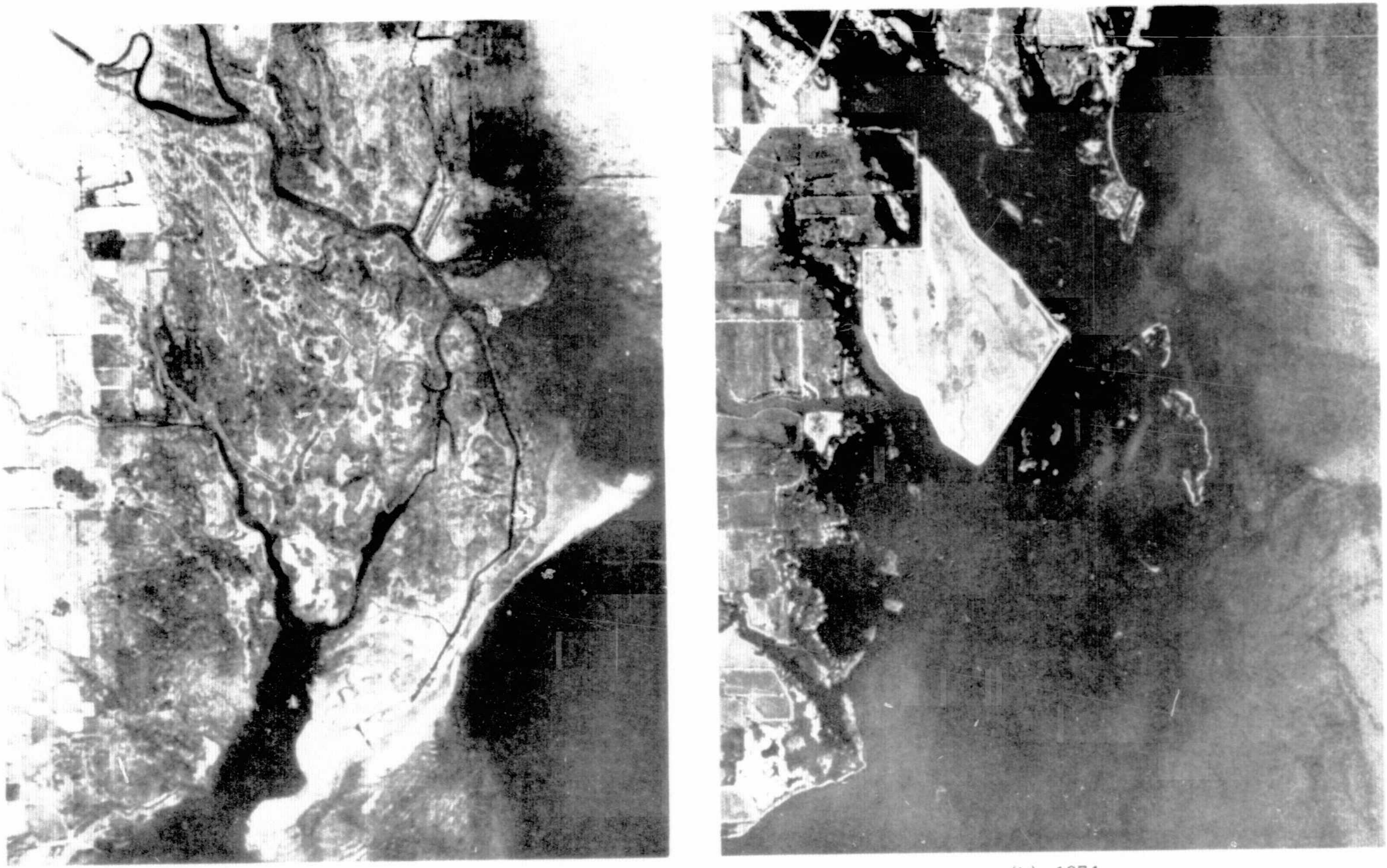


FIGURE 28. POINTE MOUILLEE STATE GAME AREA



(a) 1935

(b) 1971

FIGURE 29. POINTE MOUILLEE, MICHIGAN, LOSS OF WILDLIFE HABITAT BY 36 YEARS OF EROSION.

grow and mature; the area is flooded in the fall. The use of benchmark vegetation inventory data in this context then would be to measure the effects of the drawdown date in the spring, flooding depth in the fall, artificial planting of certain food species, etc.

To determine if a multispectral system could aid in providing the timely information required for this objective, data was acquired over the site by ERIM on 29 August 1972. Multispectral signature recognition was the processing method employed to extract the resource-related information, and the results are shown in Figure 30 [43].

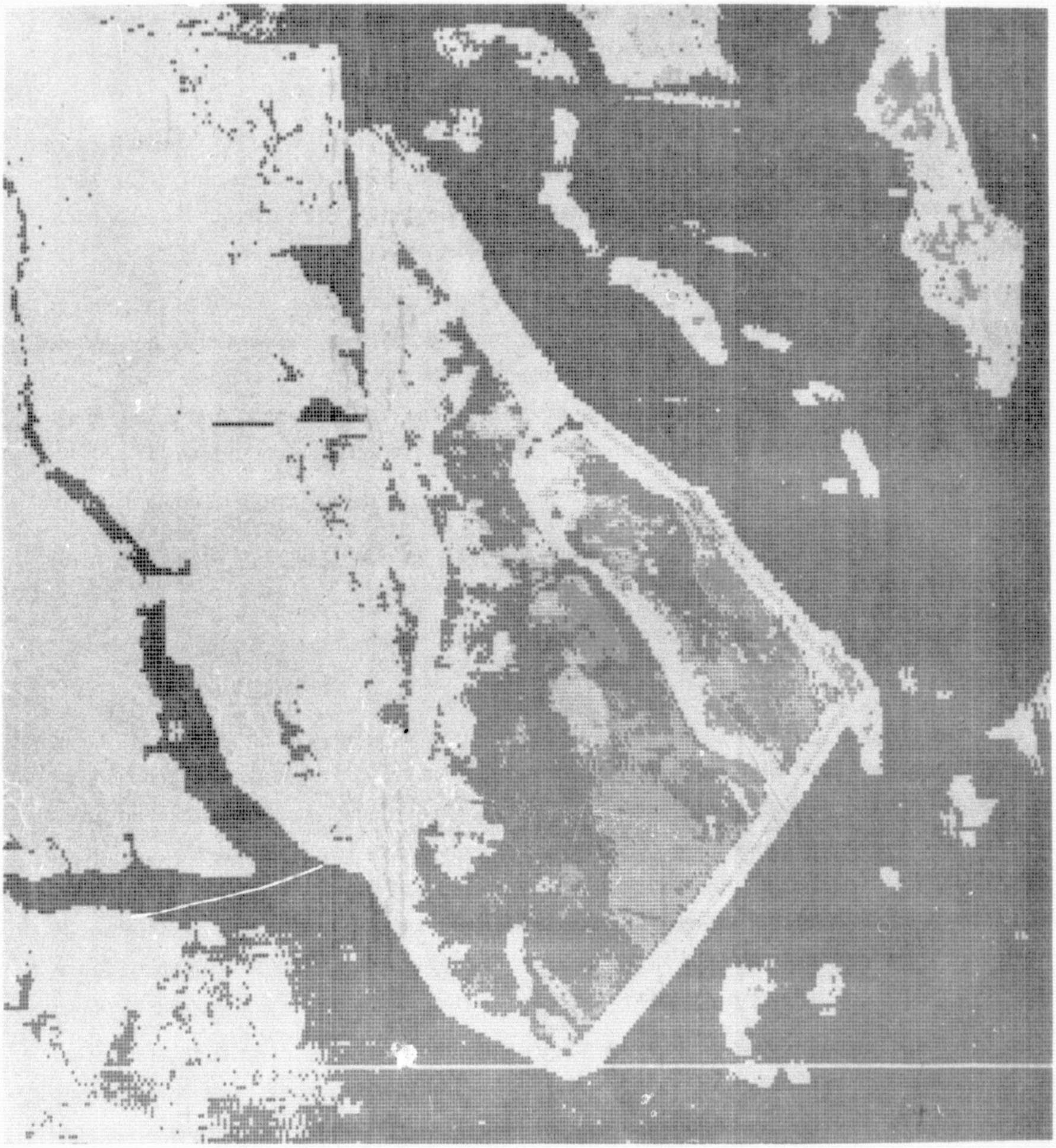
In addition to open surface water, which was included to provide a locational reference, five important classes of vegetation were successfully mapped. If these classes are then grouped into two general categories—valuable food plants and less suitable vegetation—it rapidly becomes clear that almost half of the area was covered by the less desirable vegetation, while only one-quarter of the area supported smartweed, the single most valuable food:

COVER TYPE	AREA FROM COMPUTER MAP	AREA FROM LARGE-SCALE PHOTOGRAPHY AND FIELD CHECKING
Open water	50.3	43.2
Smartweed	91.9	90.9
Other desirable emergent vegetation species	124.1	109.2
Less suitable vegetation	115.2	126.6
TOTAL	381.5	368.9

Analysis of the above data and map showed that there were two types of non-productive areas: areas of dead vegetation and areas of non-productive vegetation such as upland grasses or brush. Field investigations of the dead vegetation revealed it to be last year's smartweed. On the basis of this evidence DNR biologists hypothesized that the water level in the dike had not been lowered sufficiently during the spring of the current year to permit the smartweed to germinate. The identification of the areas of less suitable non-marsh vegetation provided a method of locating the areas within the dike where it is necessary to increase winter flooding.

Before the initiation of this project, all the management decisions mentioned above were made on the basis of the refuge manager's intuition. While these decisions are typically sound, having their basis in many years' experience, the lack of quantitative data to support them does little to establish effective guidelines. In the words of the resident manager of Pointe Mouillee, "I've been here 15 years and if I should get transferred or take another job, there'd be practically nothing on record to guide the next guy."* The results of this project show that this no longer need be the case.

*Personal communication, Mr. Jim Foote, Wildfowl Specialist, Pointe Mouillee State Game Area, 25 August 1972.



LEGEND

Green	- Smartweed	* Green	- Mixed Grasses
Θ Red	- Pigweed	Red	- Vegetated
* Blue	- Mixed Smartweed and Pigweed	• Red	- Dead Vegetation
		Blue	- Open Water

FIGURE 30. DIGITAL MAP OF IMPORTANT FOOD AND COVER VEGETATION IN DIKED PORTION OF POINTE MOUILLEE STATE GAME AREA. Data collected 29 August 1972.

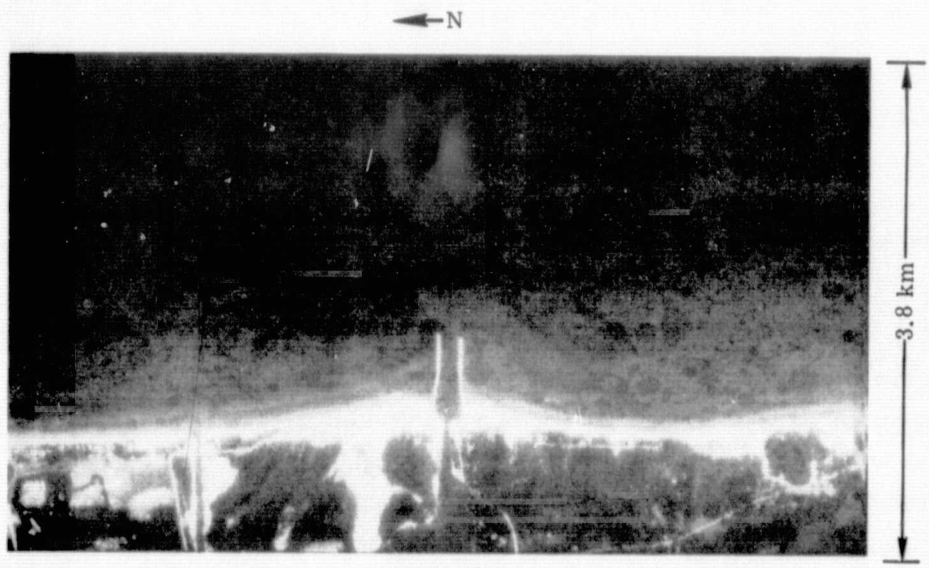
2.5 FUTURE USES OF EXISTING AIRCRAFT SENSOR DATA

While airborne sensor data were initially collected to satisfy certain experimenters' desires, the fact that these experimenters collected ground information at the time of overflight makes the combination of ground and aircraft data potentially useful for purposes other than that for which it was originally collected. Further, periodic coverage of some sites occurred between 1966 and 1974, and these data may be useful in illustrating changes which have taken place.

There are at least three main uses for the historical airborne sensor data base: the illustration and quantification of change; the use of data to better define the configuration and operating parameters of future sensors; and in tests of multistage sampling where airborne data has been collected in conjunction with spacecraft data.

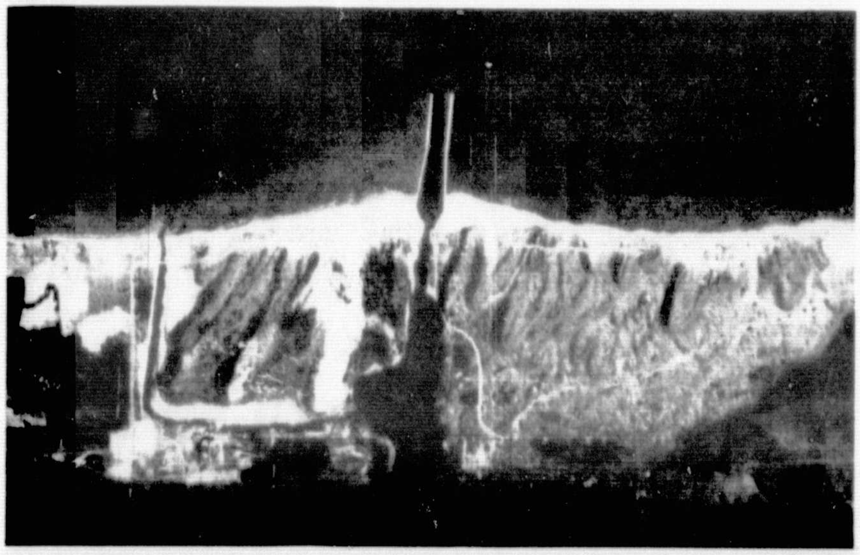
Change detection and quantification is of great interest to both natural resource managers and urban planners. For example, a manager may want to know how quickly a forest fire burn area is being revegetated, or how fast a beach is eroding. An urban planner may want to know how much new residential area is being added to a city. Even the lack of change may be important. If a power plant is installed and no changes in the shoreline are seen after a number of years of operation, one might conclude that the plant had no effect on the shoreline. The ERIM scanner system has covered several such areas periodically from 1966 to 1974. The areas are listed in later sections. In each of these areas, change detection is possible. One example, a section of the Lake Michigan shoreline south of Grand Haven, Michigan, can be seen in Figure 31. The breakwater shown is the cooling water intake for a nuclear power plant. The heated water is discharged through a canal south of the intake. Figure 31 shows imagery taken over a five year period, from 1969-1974. Other imagery collected at yearly intervals over the period was also examined. No major changes in the shoreline or area surrounding the plant are discernible on the fifteen-meter resolution imagery. This places an upper limit on the amount of change which has occurred during the five years the plant has been in operation. In fairness, it should be noted that the plant was operating at reduced capacity for part of this period. Other illustrations of change detection and quantification were discussed in the Forestry, Waterfowl Habitat, and Power Plant Discharges case studies previously presented.

A second valuable use of the existing airborne-sensor data base is in studies to define the configuration and operating parameters of future sensors, especially spacecraft sensors. The aircraft data are particularly well suited to these studies because of their large number of spectral bands, the relatively fine spatial resolution as compared to expected spacecraft sensors, and the relatively high radiometric precision of aircraft multispectral data. In studies discussed in the Agriculture Case Study, the effect of number of spectral bands, spatial resolution, and radiometric precision on the ability to map Corn Belt Crops and to measure their acreage was examined. Further tests of this sort are desirable to verify the conclusions reached from



Plant Intake Plant Outlet

(a) 11 September 1969, 0930 hrs, 5000 ft (1524 m) AGL



(b) 24 April 1974, 1030 hrs, 8000 ft (2438 m) AGL

FIGURE 31. IMAGERY OF POWER PLANT SITE NEAR GRAND HAVEN, MICHIGAN. 0.62-0.68 μm.

the analysis of one data set. Further, it would be desirable to assess the importance of the thermal channel in pattern recognition of agricultural crops as a function of the time of overflight, and to assess the effect of having a thermal band resolution somewhat larger than the resolution of the other bands. Aircraft data sets exist to verify conclusions reached and to study these additional factors. Although the illustrations discussed have been from agriculture, data sets also exist for other disciplines.

A third potentially useful application of airborne sensor data is in multistage sampling studies. The data most useful for these studies are those collected in conjunction with high-altitude aircraft and satellite overpasses. In multistage sampling, progressively more precise estimates of the resources of a large area are obtained through the analysis of data of higher and higher spatial resolution. The higher resolution data do not cover the entire area to be surveyed; they are samples of the area. In typical implementations, the fraction of the total area sampled by data of a given resolution decreases as the resolution increases. In typical multistage experiments implemented to date, photographic data have been collected and interpreted to provide information about forest resources and agriculture. But multistage experiments can also be conducted with machine-proccessed satellite and aircraft data to obtain more accurate estimates of resources. Several data sets exist which can be used for multistage experiments. They are those which were flown as satellite underflights, and are listed in Table 1.

TABLE 1. AIRCRAFT MISSIONS WITH NEAR-SIMULTANEOUS SATELLITE COVERAGE

Flight Date	Flight Time	Site	Discipline	NASA Project No.	NASA Mission No.
30 Jan 1974	1100	Wabash Basin, Ind.	Multi	EREP (397)	87 m
18 Sep 1973	1000	L. Michigan	Multi	EREP (450)	85 m
11 Sep 1973	0545	L. Ontario	Hydrology	EREP (427)	85 m
10 Sep 1973	1200	L. Ontario	Hydrology	EREP (427)	85 m
7 Sep 1973	1600	L. Michigan	Multi	EREP (450)	85 m
7 Sep 1973	1345	NW Michigan	Forestry, Agric	ERTS (321)	85 m
6 Sep 1973	1000	So. Michigan	Agric	ERTS (136)	85 m
12 Aug 1973	0830	Woodworth, N.D.	Game Management	EREP (486)	85 m
5 Aug 1973	0900	So. Michigan	Agric	EREP (410, 456, 472)	85 m
25 Jun 1973	1015	Eaton Co.	Agric	ERTS (321)	82 m
10 Jun 1973	0830	Wabash Basin, Ind.	Multi	EREP (397)	81 m
8 Jun 1973	0930	Eaton Co., Mich.	Agric	ERTS (321)	82 m
12 May 1973	0730	Woodworth, N.D.	Game Management	EREP (486)	81 m
4 May 1973	0930	Wabash Basin, Ind.	Multi	ERTS (049)	78 m/80 m
6 Apr 1973	1300	NY Bight, N.Y.	Hydro	ERTS (081)	74 m/77 m
5 Apr 1973	0930	So. Michigan	Radar, Soil Moisture	ERTS (072)	73 m/76 m
25 Mar 1973	1000	Lake Ontario	Hydro	ERTS (114)	75 m
24 Mar 1973	0930	Lake Ontario	Hydro	ERTS (114)	75 m
2 Jan 1973	1000	Wabash Basin, Ind.	Multi	ERTS (049)	71 m
17 Nov 1972	0900	Tampa Bay, Fla.	Hydro	ERTS (081)	68 m
16 Nov 1972	0900	SE Florida	Hydro	ERTS (081)	68 m
19 Oct 1972	0930	Eaton Co., Mich.	Agric	ERTS (321)	65 m
17 Oct 1972	1000	Wabash Basin, Ind.	Multi	ERTS (049)	67 m
1 Oct 1972	0700	So. California	Geol	ERTS (648)	66 m
30 Sep 1972	1200	So. California	Geol	ERTS (648)	66 m
14 Sep 1972	1300	Eaton Co., Mich.	Multi	ERTS (321)	65 m
14 Sep 1972	1300	Oakworm Infestation	Forestry	ERTS (321)	65 m
7 Sep 1972	0830	L. Ontario	Hydro	ERTS (114)	64 m
29 Aug 1972	1400	Oakland Co., Mich.	Land Use	ERTS (086)	63 m
25 Aug 1972	1000	Eaton Co., Mich.	Multi	ERTS (136/321)	63 m

TABLE 1. AIRCRAFT MISSIONS WITH NEAR-SIMULTANEOUS SATELLITE COVERAGE (Concluded)

Flight Date	Flight Time	Site	Discipline	NASA Project No.	NASA Mission No.
19 Aug 1972	0900	Tampa Bay, Fla.	Hydro	ERTS (081)	62 m
19 Aug 1972	0900	SE Florida	Hydro	ERTS (081)	62 m
18 Aug 1972	0900	SE Florida	Hydro	ERTS (081)	62 m
16 Aug 1972	0900	NY Bight, N.Y.	Hydro	ERTS (081)	62 m
13 Aug 1972	0930	Eaton Co., Mich.	Multi	ERTS (136/321)	63 m
10 Aug 1972	1030	Wabash Basin, Ind.	Multi	ERTS (049)	61 m
9 Aug 1972	0830	Wabash Basin, Ind.	Multi	ERTS (049)	61 m
28 July 1972	1700	Woodworth, N.D.	Game Management	ERTS (255)	60 m
24 July 1972	1015	No. Great Plains, S.D.	Multi	ERTS (119)	60 m
23 July 1972	1015	No. Great Plains, S.D.	Multi	ERTS (119)	60 m
22 July 1972	1015	No. Great Plains, S.D.	Multi	ERTS (119)	60 m
25 May 1972	1130	Black Hills, S.D.	Forestry	ERTS (226)	56 m
25 May 1972	0745	Black Hills, S.D.	Forestry	ERTS (226)	56 m
24 May 1972	0830	Black Hills, S.D.	Forestry	ERTS (226)	56 m
19 May 1972	0730	Woodworth, N.D.	Game Management	ERTS (255)	56 m

3
CATALOG OF IMAGERY FROM ERIM AIRBORNE SYSTEMS

The imagery of the earth's surface mapped by ERIM airborne sensors for earth resources investigations over the past nine years has been listed in several ways to aid investigators who may wish to make further use of the data. The sources of the imagery include (1) the M7 multispectral scanner developed by ERIM in 1971 to provide common registration of radiometrically calibrated spectral bands in the ultraviolet, visible and infrared, (2) the M5 multispectral scanner developed by ERIM in 1966 through modification of military reconnaissance scanners to provide multiple, radiometrically calibrated spectral bands, (3) the M1A1 scanner developed by ERIM through modification of a military reconnaissance scanner in 1967 to provide, among other things, magnetic tape recording of thermal imagery, and (4) the X- and L-band side-looking, airborne radar (SLAR) system developed by ERIM in the early 1960's for military reconnaissance purposes and made available for earth resources investigations in the late 1960's. The performance of these systems is described briefly in Section 4 of this report.

The original, inflight recording of imagery from these systems is stored at ERIM in the form of analog magnetic tape for the scanners and photographic film for the SLAR system. The imagery is available to all who receive proper authorization and who pay the cost of retrieval. As an aid in data retrieval, the cataloged information on MSS data is stored in computer memory at ERIM. Thus the computer can be used to search for particular data coverage of a specific site. Information on the ERIM processed MSS data is also stored in the computer memory. The procedure for obtaining either original or processed data is described in Section 5.4 of this report.

The continuing usefulness of this imagery is thought to be primarily in showing scene changes as a function of time and in comparing the appearance of a common scene at optical and radar wavelengths. Therefore, sites with multiple calendar or multi-sensor coverage are listed separately with the site as the index key. The index key for storage of imagery from the various airborne sensors is flight date and time. The listing of imagery from each sensor uses this ERIM storage index. The imagery is listed both by missions and by separate flights within a mission. Since the airborne imagery data sets do not include ground observations or measurements at the site, the principal investigator's name, organization, and his publications using the data are noted for reference.

3.1 LISTING OF SITES WITH MULTIPLE COVERAGE

Multiple coverage of a site, for this report, occurs whenever that site is repeatedly mapped by the same type of sensor with a time period of a week or more between missions, or when a site is mapped by two different types of sensors. Repeated mapping of a site, either sequentially or at different times of day over a several-day period making up a mission, is not considered multiple coverage.

3.1.1 MULTIPLE MISSION COVERAGE AT OPTICAL WAVELENGTHS

A mission is defined as one or more flights over a site during one field deployment, or as a series of flights to accomplish total mapping of a site. Usually a mission is accomplished over a period of less than one week in calendar time. Within the listing in Table 2 of sites with multiple calendar coverage at optical wavelengths, each flight is listed by flight date and time index. In addition, more specific information is noted on the site location, actual time of data collection, the scientific discipline concerned with the imagery and the number of imagery spectral bands in each wavelength region. Common specific area coverage for all missions with multiple calendar coverage has not been established but the flights have been grouped alphabetically by state and county within the state. Information for those missions which covered more than one county are listed under the first county in alphabetical sequence and then referenced under the other counties.

3.1.2 MULTIPLE FLIGHT COVERAGE BY MSS AND SLAR

Airborne optical and radar imaging sensor developments and data analysis have traditionally been separate, uncoordinated programs. Thus, very little imagery exists of common sites at both optical and radar wavelengths. In Table 3 we have listed sites which have been mapped by ERIM's airborne optical and radar imaging systems. Whether or not exactly the same areas at the sites were mapped by both systems has not been established for all cases, but we know that common areas were mapped for most sites listed. Again the flights are grouped alphabetically by state and county within the state.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS

Sheet 1 of 32 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CALIFORNIA											
Mono County											
Mono Lake	EJBH,BJ,AJ,AH-003	23Sep68	0900	1752	1848	Geology	0	7	5	2	2
	EJBH,BJ,AJ,AH-003	24May66	1000	2010	2042	Multi	1	9	5	2	1
Plumes County											
Bucks Lake	DJPK-020	24Oct69	1200	2045	2110	Forestry	0	7	6	0	1
	DJPK-020	16Jul69	1000	2024	2117	Forestry	0	7	5	1	1
	DJPK-020	20Sep68	0900	1900	2146	Multi	0	7	6	1	1
	DJPK-020	20May66	0445	1356	1500	Multi	1	9	5	2	1
	DJPK-020	19May66	1400	0037	0102	Multi	1	9	5	2	1
San Bernardino County											
Lavic Lake/Pisgah Crater	EJEF-002	01Oct72	0700	1345	1505	Geology	1	5	3	0	3
	EJEF-002	30Sep72	1200	2102	2222	Geology	1	5	3	0	3
	EJEF-002	30Oct70	0730	1603	1645	Geology	0	9	3	0	4
	EJEF-002	29Oct70	0800	1713	1756	Geology	1	9	3	0	4
San Joaquin County											
Manteca	DJPH	24May66	1000	1900	n/a	Multi	1	9	5	2	1
	DJPH	24May66	0530	1432	1443	Multi	0	0	1	2	1
	DJPH	17May66	1330	2226	2243	Multi	1	9	5	2	1
Yolo County											
Davis	DJPJ-049	20Sep68	0900	1900	2146	Multi	0	7	6	1	1
	DJPJ-049	26May66	1330	2323	0024	Multi	1	9	5	2	1
	DJPJ-049	24May66	0530	1357	1405	Multi	0	0	1	2	1
	DJPJ-049	17May66	1330	2308	2334	Multi	1	9	5	2	1
FLORIDA											
Broward County											
SE Coast of Florida	GHKL,KM	16Nov72	0900	1442	1647	Oceanog.	1	8	2	0	1
	GHKL,KM	19Aug72	0900	1304	1316	Oceanog.	1	8	2	0	1
	GHKL,KM	18Aug72	0900	1236	1534	Oceanog.	1	8	2	0	1
	GHKL	10Mar70	0830	1433	1705	Oceanog.	0	9	6	1	1
	GHKL	07Sep67	0730	1337	1554	Oceanog.	0	7	6	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 2 of 32 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Dade County											
SE Coast of Florida	(See Broward County)										
Hillsborough County											
Tampa Bay	GHHN-233	17Nov72	0900	1448	1555	Hydrology	1	8	2	0	1
	GHHN-233	19Aug72	0900	1423	1538	Hydrology	1	8	2	0	1
	GHHN-233	21Sep70	0430	0855	1021	Hydrology	0	0	0	0	4
	GHHN-233	20Sep70	0330	0744	0921	Hydrology	0	0	0	0	4
	GHHN-233	19Sep70	0800	1222	1415	Hydrology	1	9	6	0	1
	GHHN-233	18Sep70	0830	1245	1435	Hydrology	1	9	6	0	1
	GHHN-233	06Sep67	0400	1153	1219	Hydrology	0	0	2	1	1
	GHHN-233	05Sep67	1200	1659	1806	Hydrology	1	9	6	1	1
Manatee County											
Tampa Bay	(See Hillsborough County)										
Palm Beach County											
SE Coast of Florida	(See Broward County)										
Pinellas County											
Tampa Bay	(See Hillsborough County)										
Polk County											
Bartow	GHHN,JN	21Sep70	0430	0855	1021	Geology	0	0	0	0	4
	GHHN,JN	20Sep70	0330	0744	0921	Geology	0	0	0	0	4
	GHHN,JN	19Sep70	0800	1222	1415	Geology	1	9	6	0	1
	GHHN,JN	18Sep70	0830	1245	1435	Geology	1	9	6	0	1
	GHHN,JN	06Sep67	0400	1153	1219	Geology	0	0	2	1	1
	GHHN,JN	05Sep67	1200	1659	1806	Geology	1	9	6	1	1
ILLINOIS											
Fayette County											
Vandalia	GJAK,AJ	21Aug73	0900	1430	1820	Agric.	0	7	4	0	1
	GJAK,AJ	05Jul73	0900	1543	2022	Agric.	0	7	4	0	1
Ford County											
Paxton	GJBL	13Aug70	1430	1831	2044	Multi	0	9	6	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

Sheet 3 of 32 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Paxton	GJBL	01Jul70	0930	1344	1710	Agric.	0	9	6	1	1
Lee County											
Amboy	GJAM-044	20Aug73	1200	1909	2023	Agric.	0	7	4	0	1
	GJAM-044	05Jul73	0900	1543	2022	Agric.	0	7	4	0	1
Livingston County											
Pontiac	GJBL-044	20Aug73	1200	1909	2023	Agric.	0	7	4	0	1
	GJBL-044	05Jul73	0900	1543	2022	Agric.	0	7	4	0	1
McLean County											
Arrowsmith	GJBL	13Aug70	1430	1831	2044	Multi	0	9	6	1	1
	GJBL	01Jul70	0930	1344	1710	Agric.	0	9	6	1	1
Bloomington	GJAL	13Aug70	1430	1831	2044	Multi	0	9	6	1	1
	GJAL	01Jul70	0930	1344	1710	Agri	0	9	6	1	1
INDIANA											
Benton County											
CB Flight Line 209	GJCL-277	24Sep71	1300	1705	1755	Agric.	0	8	3	0	1
	GJCL-277	14Sep71	1300	1657	1809	Agric.	0	8	3	0	1
	GJCL-277	25Aug71	1300	1632	1733	Agric.	0	8	3	0	1
	GJCL-277	13Aug71	1300	1616	1714	Agric.	0	8	3	0	1
	GJCL-277	05Aug71	1300	1600	1735	Agric.	0	8	3	0	1
	GJCL-277	12Jul71	1300	1755	1902	Agric.	0	8	3	0	1
	GJCL-277	28Jun71	1300	1800	1914	Agric.	1	8	5	1	1
	GJCL-277	17May71	1300	1808	1904	Agric.	0	9	6	1	1
Carroll County											
Monticello	(See White County)										
Clay County											
CB Flight Line 217	(See Vigo County)										
Daviess County											
Maysville	GJCL	11Sep70	1300	1507	1644	Agric.	0	9	6	1	1
	GJCL	11Sep70	0900	1007	1144	Agric.	0	9	6	1	1
	GJCL	05Sep70	1400	2004	2142	Agric.	0	9	6	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Maysville	GJCL	05Sep70	0900	1552	1810	Agric.	0	9	6	1	1
	GJCL	24Aug70	1630	2143	2323	Agric.	0	9	6	1	1
	GJCL	24Aug70	1100	1702	1834	Agric.	0	9	6	1	1
Dubois County											
CB Flight Line 224	(See Martin County)										
Fountain County											
CB Flight Line 211	GJCL-277	24Sep71	1000	1804	1905	Agric.	0	8	3	0	1
	GJCL-277	14Sep71	1000	1902	1958	Agric.	0	8	3	0	1
	GJCL-277	28Aug71	1000	1509	1616	Agric.	0	8	3	0	1
	GJCL-277	11Aug71	1000	1608	1650	Agric.	1	8	5	1	1
	GJCL-277	29Jul71	1000	1455	1555	Agric.	1	8	5	1	1
	GJCL-277	16Jul71	1000	1416	1459	Agric.	1	8	5	1	1
	GJCL-277	29Jun71	1000	1510	1603	Agric.	1	8	5	1	1
	GJCL-277	21May71	1000	1545	1631	Agric.	0	9	6	1	1
CB Flight Line 212	(See Montgomery County)										
CB Flight Line 213	(See Parke County)										
Fulton County											
Purdue - Culver Experimental											
Farm	(See Marshall County)										
Gibson County											
CB Flight Line 225	GJCJ-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJCJ-277	15Sep71	1230	1645	1737	Agric.	0	8	3	0	1
	GJCJ-277	28Aug71	1230	1622	1710	Agric.	0	8	3	0	1
	GJCJ-277	12Aug71	1230	1544	1637	Agric.	0	8	3	0	1
	GJCJ-277	27Jul71	1230	1500	1555	Agric.	0	8	3	0	1
	GJCJ-277	16Jul71	1230	1620	1709	Agric.	0	8	3	0	1
	GJCJ-277	30Jun71	1230	1511	1602	Agric.	0	8	3	0	1
	GJCJ-277	22May71	1000	1440	1533	Agric.	0	9	6	1	1
Grant County											
Huntington	(See Huntington County)										
Greene County											
CB Flight Line 220	GJCJ,GJDJ-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 220	GJCJ,GJDJ-277	05Oct71	0900	1751	1855	Agric.	0	8	3	0	1
	GJCJ,GJDJ-277	15Sep71	0900	1749	1850	Agric.	0	8	3	0	1
	GJCJ,GJDJ-277	29Aug71	1330	1916	1928	Agric.	0	8	3	0	1
	GJCJ,GJDJ-277	29Aug71	0900	1724	1847	Agric.	0	8	3	0	1
	GJCJ,GJDJ-277	12Aug71	0900	1650	1834	Agric.	1	8	5	1	1
	GJCJ,GJDJ-277	29Jul71	1130	1604	1730	Agric.	1	8	5	1	1
	GJCJ,GJDJ-277	27Jul71	0900	1700	1807	Agric.	1	8	5	1	1
	GJCJ,GJDJ-277	16Jul71	0900	1723	1824	Agric.	1	8	5	1	1
	GJCJ,GJDJ-277	07Jul71	0900	1550	1719	Agric.	1	8	5	1	1
	GJCJ,GJDJ-277	30Jun71	0900	1614	1727	Agric.	1	8	5	1	1
	GJCJ,GJDJ-277	22May71	1130	1546	1644	Agric.	0	9	6	1	1
Linton	GJCK,GJCJ-250	04May73	0900	1554	1925	Multi	0	8	3	0	1
	GJCK,GJCJ-250	09Aug72	0830	1632	1802	Multi	0	8	3	0	1
Worthington	GJCK,GJCL	11Sep70	1300	1507	1644	Agric.	0	9	6	1	1
	GJCK,GJCL	11Sep70	0900	1007	1144	Agric.	0	9	6	1	1
	GJCK,GJCL	05Sep70	1400	2004	2142	Agric.	0	9	6	1	1
	GJCK,GJCL	05Sep70	0900	1552	1810	Agric.	0	9	6	1	1
	GJCK,GJCL	24Aug70	1630	2143	2323	Agric.	0	9	6	1	1
	GJCK,GJCL	24Aug70	1100	1702	1834	Agric.	0	9	6	1	1
Huntington County											
Huntington	GJEL-044	21Aug73	0900	1430	1820	Agric.	0	7	4	0	1
	GJEL-044	07Jul73	0815	1346	1500	Agric.	0	7	4	0	1
	GJEL-044	06Jul73	0900	1541	1808	Agric.	0	7	4	0	1
	GJEL-044	10Aug72	1030	1550	1731	Multi	0	8	3	0	1
Jasper County											
CB Flight Line 206	GJCL-277	24Sep71	1300	1705	1755	Agric.	0	8	3	0	1
	GJCL-277	14Sep71	1300	1657	1809	Agric.	0	8	3	0	1
	GJCL-277	29Aug71	1300	1632	1733	Agric.	0	8	3	0	1
	GJCL-277	13Aug71	1300	1616	1714	Agric.	0	8	3	0	1
	GJCL-277	31Jul71	1300	1530	1618	Agric.	0	8	3	0	1
	GJCL-277	31Jul71	1130	1515	1530	Agric.	1	8	5	1	1
	GJCL-277	21Jul71	1130	1421	1806	Agric.	0	8	3	0	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 206	GJCL-277	13Jul71	1130	1830	1913	Agric.	1	8	5	1	1
	GJCL-277	12Jul71	1300	1755	1902	Agric.	0	8	3	0	1
	GJCL-277	07Jul71	0900	1550	1719	Agric.	1	8	5	1	1
	GJCL-277	28Jun71	1300	1800	1914	Agric.	1	8	5	1	1
	GJCL-277	17May71	1300	1808	1904	Agric.	0	9	6	1	1
CB Flight Line 207	GJCL-277	24Sep71	1300	1705	1755	Agric.	0	8	3	0	1
	GJCL-277	14Sep71	1300	1657	1809	Agric.	0	8	3	0	1
	GJCL-277	29Aug71	1300	1632	1733	Agric.	0	8	3	0	1
	GJCL-277	13Aug71	1300	1616	1714	Agric.	0	8	3	0	1
	GJCL-277	31Jul71	1300	1537	1618	Agric.	0	8	3	0	1
	GJCL-277	31Jul71	1130	1515	1530	Agric.	1	8	5	1	1
	GJCL-277	21Jul71	1130	1421	1806	Agric.	0	8	3	0	1
	GJCL-277	13Jul71	1130	1830	1913	Agric.	1	8	5	1	1
	GJCL-277	12Jul71	1300	1755	1902	Agric.	0	8	3	0	1
	GJCL-277	28Jun71	1300	1800	1914	Agric.	1	8	5	1	1
	GJCL-277	17May71	1300	1808	1904	Agric.	0	9	6	1	1
Knox County											
CB Flight Line 221	GJCJ-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJCJ-277	15Sep71	1230	1645	1737	Agric.	0	8	3	0	1
	GJCJ-277	28Aug71	1230	1622	1710	Agric.	0	8	3	0	1
	GJCJ-277	12Aug71	1230	1544	1637	Agric.	0	8	3	0	1
	GJCJ-277	27Jul71	1230	1500	1555	Agric.	0	8	3	0	1
	GJCJ-277	16Jul71	1230	1620	1709	Agric.	0	8	3	0	1
	GJCJ-277	30Jun71	1230	1511	1602	Agric.	0	8	3	0	1
	GJCJ-277	22May71	1000	1440	1533	Agric.	0	9	6	1	1
CB Flight Line 223	GJCJ-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJCJ-277	15Sep71	1230	1645	1737	Agric.	0	8	3	0	1
	GJCJ-277	28Aug71	1230	1622	1710	Agric.	0	8	3	0	1
	GJCJ-277	12Aug71	1230	1544	1637	Agric.	0	8	3	0	1
	GJCJ-277	27Jul71	1230	1500	1555	Agric.	0	8	3	0	1
	GJCJ-277	16Jul71	1230	1620	1709	Agric.	0	8	3	0	1
	GJCJ-277	30Jun71	1230	1511	1602	Agric.	0	8	3	0	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 223	GJCJ-277	22May71	1000	1440	1533	Agric.	0	9	6	1	1
CB Flight Line 225	(See Gibson County)										
LaPorte County											
CB Flight Line 201	(See Porter County)										
LaCrosse	GJDM	11Sep70	1300	1507	1644	Agric.	0	9	6	1	1
	GJDM	11Sep70	0900	1007	1144	Agric.	0	9	6	1	1
	GJDM	05Sep70	1400	2004	2142	Agric.	0	9	6	1	1
	GJDM	05Sep70	0900	1552	1810	Agric.	0	9	6	1	1
	GJDM	24Aug70	1630	2143	2323	Agric.	0	9	6	1	1
	GJDM	24Aug70	1100	1702	1834	Agric.	0	9	6	1	1
Lake County											
CB Flight Line 204	GJCM-277	24Sep71	1130	1554	1659	Agric.	0	8	3	0	1
	GJCM-277	14Sep71	1130	1545	1649	Agric.	0	8	3	0	1
	GJCM-277	29Aug71	1130	1508	1620	Agric.	0	8	3	0	1
	GJCM-277	13Aug71	1130	1501	1609	Agric.	1	8	5	1	1
	GJCM-277	05Aug71	1130	1505	1637	Agric.	1	0	2	1	0
	GJCM-277	13Jul71	1130	1830	1913	Agric.	1	8	5	1	1
	GJCM-277	12Jul71	1130	1639	1745	Agric.	1	8	5	1	1
	GJCM-277	28Jun71	1130	1646	1748	Agric.	1	8	5	1	1
	GJCM-277	17May71	1130	1641	1739	Agric.	0	9	6	1	1
Marion County											
Indianapolis	GJDK	04May73	0930	1554	1925	Multi	0	8	3	0	1
	GJDK	02Jan73	1000	1719	1743	Multi	0	8	3	0	1
	GJDK	10Aug72	1030	1550	1731	Multi	0	8	3	0	1
	GJDK	28Apr67	0900	1555	1735	Multi	1	9	3	1	1
Marshall County											
Purdue - Culver Experimental	GJDL	15Sep66	1200	1741	1928	Agric.	1	9	5	2	1
Farm	GJDL	15Sep66	0730	1320	1528	Agric.	1	9	5	2	1
	GJDL	29Jul66	0800	1327	1428	Agric.	0	9	5	2	0
	GJDL	28Jul66	1200	1728	1839	Agric.	0	9	5	2	0
	GJDL	06May66	1330	n/a	n/a	Agric.	1	9	5	2	1
Martin County											

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 222	GJDJ-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1
	GJDJ-277	05Oct71	0900	1751	1855	Agric.	0	8	3	0	1
	GJDJ-277	15Sep71	0900	1749	1850	Agric.	0	8	3	0	1
	GJDJ-277	29Aug71	1330	1916	1928	Agric	0	8	3	0	1
	GJDJ-277	28Aug71	0900	1724	1847	Agric.	0	8	3	0	1
	GJDJ-277	12Aug71	0900	1650	1834	Agric.	1	8	5	1	1
	GJDJ-277	27Jul71	0900	1700	1807	Agric.	1	8	5	1	1
	GJDJ-277	16Jul71	0900	1723	1824	Agric.	1	8	5	1	1
	GJDJ-277	07Jul71	0900	1550	1719	Agric.	1	8	5	1	1
	GJDJ-277	30Jun71	0900	1614	1727	Agric.	1	8	5	1	1
	GJDJ-277	22May71	1130	1546	1644	Agric.	0	9	6	1	1
CB Flight Line 224	GJDJ-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1
	GJDJ-277	05Oct71	0900	1751	1855	Agric.	0	8	3	0	1
	GJDJ-277	15Sep71	0900	1749	1850	Agric.	0	8	3	0	1
	GJDJ-277	28Aug71	0900	1724	1847	Agric.	0	8	3	0	1
	GJDJ-277	12Aug71	0900	1650	1834	Agric.	1	8	5	1	1
	GJDJ-277	27Jul71	0900	1700	1807	Agric.	1	8	5	1	1
	GJDJ-277	16Jul71	0900	1723	1824	Agric.	1	8	5	1	1
	GJDJ-277	07Jul71	0900	1550	1719	Agric.	1	8	5	1	1
	GJDJ-277	30Jun71	0900	1614	1727	Agric.	1	8	5	1	1
	GJDJ-277	22May71	1130	1546	1644	Agric.	0	9	6	1	1
Monroe County											
Bloomington	GJDK	04May73	0930	1554	1925	Multi	0	8	3	0	1
	GJDK	17Oct72	1000	1647	1758	Multi	0	8	3	0	1
	GJDK	09Aug72	0830	1632	1802	Multi	0	8	3	0	1
Montgomery County											
Beckville	GJDK,GJDL	11Sep70	1300	1507	1644	Agric.	0	9	6	1	1
	GJDK,GJDL	11Sep70	0900	1007	1144	Agric.	0	9	6	1	1
	GJDK,GJDL	05Sep70	1400	2004	2142	Agric.	0	9	6	1	1
	GJDK,GJDL	05Sep70	0900	1552	1810	Agric.	0	9	6	1	1
	GJDK,GJDL	24Aug70	1630	2143	2323	Agric.	0	9	6	1	1
	GJDK,GJDL	24Aug70	1100	1702	1834	Agric.	0	9	6	1	1

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(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Beckville	GJDK,GJDL	24Aug70	1100	1702	1834	Agric.	0	9	6	1	1
CB Flight Line 212	GJCL	24Sep71	1000	1804	1905	Agric.	0	8	3	0	1
	GJCL	14Sep71	1000	1902	1958	Agric.	0	8	3	0	1
	GJCL	28Aug71	1000	1509	1616	Agric.	0	8	3	0	1
	GJCL	17Aug71	1130	1437	1641	Agric.	0	8	3	0	1
	GJCL	11Aug71	1000	1608	1650	Agric.	1	8	5	1	1
	GJCL	29Jul71	1000	1455	1555	Agric.	1	8	5	1	1
	GJCL	16Jul71	1000	1416	1459	Agric.	1	8	5	1	1
	GJCL	29Jun71	1000	1510	1603	Agric.	1	8	5	1	1
	GJCL	21May71	1000	1545	1631	Agric.	0	9	6	1	1
Morgan County											
Bloomington	(See Monroe County)										
Newton County											
CB Flight Line 204	(See Lake County)										
Owen County											
CB Flight Line 218	GJDK-277	24Sep71	1130	1911	2014	Agric.	0	8	3	0	1
	GJDK-277	15Sep71	1130	1546	1640	Agric.	0	8	3	0	1
	GJDK-277	26Aug71	1130	1601	1750	Agric.	0	8	3	1	1
	GJDK-277	12Aug71	1130	1442	1530	Agric.	0	8	3	0	1
	GJDK-277	27Jul71	1130	1831	2012	Agric.	0	8	3	0	1
	GJDK-277	21Jul71	1130	1421	1806	Agric.	0	8	3	0	1
	GJDK-277	29Jun71	1130	1609	1758	Agric.	0	8	3	0	1
	GJDK-277	21May71	1130	1639	1746	Agric.	0	9	6	1	1
Cunot	GJDK-250	04May73	0930	1554	1925	Multi	0	8	3	0	1
	GJDK-250	09Aug72	0830	1632	1802	Multi	0	8	3	0	1
Parke County											
Cayuga	(See Vermillion County)										
CB Flight Line 213	GJCK-277	24Sep71	1000	1804	1905	Agric.	0	8	3	0	1
	GJCK-277	14Sep71	1000	1902	1958	Agric.	0	8	3	0	1
	GJCK-277	28Aug71	1000	1509	1616	Agric.	0	8	3	0	1
	GJCK-277	11Aug71	1000	1608	1650	Agric.	1	8	5	1	1
	GJCK-277	29Jul71	1000	1455	1555	Agric.	1	8	5	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 213	GJCK-277	16Jul71	1000	1416	1459	Agric.	1	8	5	1	1
	GJCK-277	29Jun71	1000	1510	1603	Agric.	1	8	5	1	1
	GJCK-277	21May71	1000	1545	1631	Agric.	0	9	6	1	1
CB Flight Line 215	GJCK-277	24Sep71	1130	1911	2014	Agric.	0	8	3	0	1
	GJCK-277	15Sep71	1130	1546	1640	Agric.	0	8	3	0	1
	GJCK-277	26Aug71	1130	1601	1750	Agric.	0	8	3	1	1
	GJCK-277	12Aug71	1130	1442	1530	Agric.	0	8	3	0	1
	GJCK-277	11Aug71	1130	1656	1728	Agric.	0	8	3	0	1
	GJCK-277	05Aug71	1300	1600	1735	Agric.	0	8	3	0	1
	GJCK-277	29Jul71	1130	1604	1730	Agric.	1	8	5	1	1
	GJCK-277	27Jul71	1130	1831	2012	Agric.	0	8	3	0	1
	GJCK-277	21Jul71	1130	1421	1806	Agric.	0	8	3	0	1
	GJCK-277	29Jun71	1130	1609	1758	Agric.	0	8	3	0	1
	GJCK-277	21May71	1130	1639	1746	Agric.	0	9	6	1	1
Pike County											
CB Flight Line 226	GJCJ-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1
	GJCJ-277	05Oct71	0900	1751	1855	Agric.	0	8	3	0	1
	GJCJ-277	15Sep71	0900	1749	1850	Agric.	0	8	3	0	1
	GJCJ-277	28Aug71	0900	1724	1847	Agric.	0	8	3	0	1
	GJCJ-277	12Aug71	0900	1650	1834	Agric.	1	8	5	1	1
	GJCJ-277	27Jul71	0900	1700	1807	Agric.	1	8	5	1	1
	GJCJ-277	16Jul71	0900	1723	1824	Agric.	1	8	5	1	1
	GJCJ-277	30Jun71	0900	1614	1727	Agric.	1	8	5	1	1
	GJCJ-277	22May71	1130	1546	1644	Agric.	0	9	6	1	1
Porter County											
CB Flight Line 201	GJDM-277	24Sep71	1130	1554	1659	Agric.	0	8	3	0	1
	GJDM-277	14Sep71	1130	1545	1649	Agric.	0	8	3	0	1
	GJDM-277	29Aug71	1130	1508	1620	Agric.	0	8	3	0	1
	GJDM-277	13Aug71	1130	1501	1609	Agric.	1	8	5	1	1
	GJDM-277	05Aug71	1130	1505	1637	Agric.	1	0	2	1	0
	GJDM-277	12Jul71	1130	1639	1745	Agric.	1	8	5	1	1
	GJDM-277	28Jun71	1130	1646	1748	Agric.	1	8	5	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 201	GJDM-277	17May71	1130	1641	1739	Agric.	0	9	6	1	1
CB Flight Line 202	GJCM-277	24Sep71	1130	1554	1659	Agric.	0	8	3	0	1
	GJCM-277	14Sep71	1130	1545	1649	Agric.	0	8	3	0	1
	GJCM-277	29Aug71	1130	1508	1620	Agric.	0	8	3	0	1
	GJCM-277	17Aug71	1130	1437	1641	Agric.	0	8	3	0	1
	GJCM-277	13Aug71	1130	1501	1609	Agric.	1	8	5	1	1
	GJCM-277	05Aug71	1130	1505	1637	Agric.	1	0	2	1	0
	GJCM-277	12Jul71	1130	1639	1745	Agric.	1	8	5	1	1
	GJCM-277	28Jun71	1130	1646	1748	Agric.	1	8	5	1	1
	GJCM-277	17May71	1130	1641	1739	Agric.	0	9	6	1	1
Posey County											
CB Flight Line 228	GJBJ,CJ-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1
	GJBJ,CJ-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJBJ,CJ-277	15Sep71	1230	1645	1737	Agric.	0	8	3	0	1
	GJBJ,CJ-277	28Aug71	1230	1622	1710	Agric.	0	8	3	0	1
	GJBJ,CJ-277	12Aug71	1230	1544	1637	Agric.	0	8	3	0	1
	GJBJ,CJ-277	27Jul71	1230	1500	1555	Agric.	0	8	3	0	1
	GJBJ,CJ-277	16Jul71	1230	1620	1709	Agric.	0	8	3	0	1
	GJBJ,CJ-277	30Jun71	1230	1511	1602	Agric.	0	8	3	0	1
	GJBJ,CJ-277	22May71	1000	1440	1533	Agric.	1	9	6	1	1
CB Flight Line 230	GJCJ,CH-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1
	GJCJ,CH-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJCJ,CH-277	15Sep71	1230	1645	1737	Agric.	0	8	3	0	1
	GJCJ,CH-277	28Aug71	1230	1622	1710	Agric.	0	8	3	0	1
	GJCJ,CH-277	12Aug71	1230	1544	1637	Agric.	0	8	3	0	1
	GJCJ,CH-277	27Jul71	1230	1500	1555	Agric.	0	8	3	0	1
	GJCJ,CH-277	16Jul71	1230	1620	1709	Agric.	0	8	3	0	1
	GJCJ,CH-277	30Jun71	1230	1511	1602	Agric.	0	8	3	0	1
	GJCJ,CH-277	22May71	1000	1440	1533	Agric.	1	9	6	1	1
Pulaski County											
CB Flight Line 205	(See Starke County)										
Franceville	GJDM,DL	11Sep70	1300	1507	1644	Agric.	0	9	6	1	1

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(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Franceville	GJDM,DL	11Sep70	0900	1007	1144	Agric.	0	9	6	1	1
	GJDM,DL	05Sep70	1400	2004	2142	Agric.	0	9	6	1	1
	GJDM,DL	05Sep70	0900	1552	1810	Agric.	0	9	6	1	1
	GJDM,DL	24Aug70	1630	2143	2323	Agric.	0	9	6	1	1
	GJDM,DL	24Aug70	1100	1702	1834	Agric.	0	9	6	1	1
Putnam County											
CB Flight Line 214	GJDK-277	24Sep71	1000	1804	1905	Agric.	0	8	3	0	1
	GJDK-277	14Sep71	1000	1902	1958	Agric.	0	8	3	0	1
	GJDK-277	28Aug71	1000	1509	1616	Agric.	0	8	3	0	1
	GJDK-277	11Aug71	1000	1608	1650	Agric.	1	8	5	1	1
	GJDK-277	05Aug71	1130	1505	1637	Agric.	1	0	2	1	0
	GJDK-277	29Jul71	1000	1455	1555	Agric.	1	8	5	1	1
	GJDK-277	16Jul71	1000	1416	1459	Agric.	1	8	5	1	1
	GJDK-277	29Jun71	1000	1510	1603	Agric.	1	8	5	1	1
	GJDK-277	21May71	1000	1545	1613	Agric.	0	9	6	1	1
CB Flight Line 216	GJDK-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJDK-277	24Sep71	1130	1911	2014	Agric.	0	8	3	0	1
	GJDK-277	15Sep71	1130	1546	1640	Agric.	0	8	3	0	1
	GJDK-277	26Aug71	1130	1601	1750	Agric.	0	8	3	1	1
	GJDK-277	12Aug71	1130	1442	1530	Agric.	0	8	3	0	1
	GJDK-277	27Jul71	1130	1831	2012	Agric.	0	8	3	0	1
	GJDK-277	21Jul71	1130	1421	1806	Agric.	0	8	3	0	1
	GJDK-277	29Jun71	1130	1609	1758	Agric.	0	8	3	0	1
	GJDK-277	21May71	1130	1639	1746	Agric.	0	9	6	1	1
Shelby County											
Shelbyville	GJEK-044	21Aug73	0900	1430	1820	Agric.	0	7	4	0	1
	GJEK-044	07Jul73	0815	1346	1500	Agric.	0	7	4	0	1
	GJEK-044	06Jul73	0900	1541	1808	Agric.	0	7	4	0	1
Spencer County											
CB Flight Line 227	GJCJ-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1
	GJCJ-277	05Oct71	0900	1751	1855	Agric.	0	8	3	0	1
	GJCJ-277	15Sep71	0900	1749	1850	Agric.	0	8	3	0	1

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(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 227	GJCJ-277	28Aug71	0900	1724	1847	Agric.	0	8	3	0	1
	GJCJ-277	12Aug71	0900	1650	1834	Agric.	1	8	5	1	1
	GJCJ-277	27Jul71	0900	1700	1807	Agric.	1	8	5	1	1
	GJCJ-277	16Jul71	0900	1723	1824	Agric.	1	8	5	1	1
	GJCJ-277	30Jun71	0900	1614	1727	Agric.	1	8	5	1	1
	GJCJ-277	22May71	1130	1546	1644	Agric.	0	9	6	1	1
Starke County											
CB Flight Lines 203 & 205	GJDM-277	24Sep71	1130	1554	1659	Agric.	0	8	3	0	1
	GJDM-277	14Sep71	1130	1545	1649	Agric.	0	8	3	0	1
	GJDM-277	29Aug71	1130	1508	1620	Agric.	0	8	3	0	1
	GJDM-277	13Aug71	1130	1501	1609	Agric.	1	8	5	1	1
	GJDM-277	31Jul71	1130	1515	1530	Agric.	1	8	5	1	1
	GJDM-277	12Jul71	1130	1639	1745	Agric.	1	8	5	1	1
	GJDM-277	28Jun71	1130	1646	1748	Agric.	1	8	5	1	1
	GJDM-277	17May71	1130	1641	1739	Agric.	0	9	6	1	1
Sullivan County											
CB Flight Line 219	GJCK-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJCK-277	24Sep71	1130	1911	2014	Agric.	0	8	3	0	1
	GJCK-277	15Sep71	1130	1546	1640	Agric.	0	8	3	0	1
	GJCK-277	28Aug71	1000	1509	1616	Agric.	0	8	3	0	1
	GJCK-277	26Aug71	1130	1601	1750	Agric.	0	8	3	1	1
	GJCK-277	12Aug71	1130	1442	1530	Agric.	0	8	3	0	1
	GJCK-277	29Jul71	1130	1604	1730	Agric.	1	8	5	1	1
	GJCK-277	27Jul71	1130	1831	2012	Agric.	0	8	3	0	1
	GJCK-277	21Jul71	1130	1421	1806	Agric.	0	8	3	0	1
	GJCK-277	29Jun71	1130	1609	1758	Agric.	0	8	3	0	1
	GJCK-277	21May71	1130	1639	1746	Agric.	0	9	6	1	1
CB Flight Line 221	(See Knox County)										
Tippecanoe County											
CB Flight Line 210	GJCL-277	24Sep71	1300	1705	1755	Agric.	0	8	3	0	1
	GJCL-277	14Sep71	1300	1657	1809	Agric.	0	8	3	0	1
	GJCL-277	29Aug71	1300	1632	1733	Agric.	0	8	3	0	1

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(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 210	GJCL-277	13Aug71	1300	1616	1714	Agric.	0	8	3	0	1
	GJCL-277	05Aug71	1300	1600	1735	Agric.	0	8	3	0	1
	GJCL-277	12Jul71	1300	1755	1902	Agric.	0	8	3	0	1
	GJCL-277	28Jun71	1300	1800	1914	Agric.	1	8	5	1	1
	GJCL-277	17May71	1300	1808	1904	Agric.	0	9	6	1	1
Lafayette Vicinity	GJCL,DL	05Sep70	0900	1552	1810	Agric.	0	9	6	1	1
	GJCL,DL	13Aug70	1430	1831	2044	Agric.	0	9	6	1	1
	GJCL,DL	11Aug70	1330	1735	1835	Agric.	0	9	6	1	1
	GJCL,DL	01Jul70	0930	1345	1710	Agric.	0	9	6	1	1
	GJCL,DL	01Jul70	0500	0941	0951	Agric.	0	0	0	1	3
	GJCL,DL	30Jun70	0930	1351	1528	Agric.	0	9	6	1	1
	GJCL,DL	06May70	1300	1905	2104	Agric.	0	9	6	1	1
	GJCL,DL	06May70	0900	1509	1642	Agric.	0	9	8	1	1
	GJCL,DL	17Dec69	1200	1812	2056	Agric.	0	7	6	1	1
	GJCL,DL	06Nov69	1100	1613	1802	Agric.	0	7	6	1	1
	GJCL,DL	06Nov69	0830	1424	1507	Agric.	0	7	6	1	1
	GJCL,DL	05Nov69	1300	1807	1924	Agric.	0	7	6	1	1
	GJCL,DL	06Aug69	1030	1522	1703	Agric.	0	7	5	1	1
	GJCL,DL	05Aug69	1030	1547	1758	Agric.	0	7	5	1	1
	GJCL,DL	05Aug69	0700	1320	1424	Agric.	0	7	5	1	1
	GJCL,DL	26Jun69	1030	n/a	n/a	Agric.	0	7	5	1	1
	GJCL,DL	25Jun69	1700	n/a	n/a	Agric.	0	7	5	1	1
	GJCL,DL	25Jun69	1100	1931	2024	Agric.	0	7	5	1	0
	GJCL,DL	27May69	1100	1718	1854	Agric.	0	7	5	1	1
	GJCL,DL	26May69	1100	1640	1803	Agric.	0	7	5	1	1
	GJCL,DL	13May69	0800	1244	1403	Agric.	0	7	5	1	1
	GJCL,DL	26Sep68	0900	1537	1649	Agric.	0	7	6	1	1
	GJCL,DL	30Jul68	0900	1531	1615	Agric.	0	7	6	1	1
	GJCL,DL	15Sep66	2030	0155	0256	Agric.	0	0	0	1	1
	GJCL,DL	15Sep66	1200	1741	1928	Agric.	1	9	5	2	1
	GJCL,DL	15Sep66	0730	1320	1528	Agric.	1	9	5	2	1
	GJCL,DL	29Jul66	0800	1327	1428	Agric.	0	9	5	2	0

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(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Lafayette Vicinity	GJCL,DL	28Jul66	1200	1728	1839	Agric.	0	9	5	2	0
	GJCL,DL	27Jul66	0815	1359	1441	Agric.	0	9	5	2	1
	GJCL,DL	26Jul66	2130	0321	0427	Agric.	0	0	0	1	1
	GJCL,DL	26Jul66	1000	1549	1717	Agric.	1	9	5	2	1
	GJCL,DL	30Jun66	1400	n/a	n/a	Agric.	1	9	5	2	1
	GJCL,DL	30Jun66	0830	1357	1527	Agric.	1	9	5	2	1
	GJCL,DL	29Jun66	2130	n/a	n/a	Agric.	0	0	0	1	1
	GJCL,DL	29Jun66	1230	1805	1836	Agric.	1	9	5	2	1
	GJCL,DL	28Jun66	1000	1716	1803	Agric.	1	9	5	2	1
	GJCL,DL	06May66	1330	n/a	n/a	Agric.	1	9	5	2	1
	GJCL,DL	05May66	1300	1832	2003	Agric.	1	9	5	2	1
Vanderburg County											
CB Flight Line 230	(See Posey County)										
Earle	GJCJ	11Sep70	1300	1507	1644	Agric.	0	9	6	1	1
	GJCJ	11Sep70	0900	1007	1144	Agric.	0	9	6	1	1
	GJCJ	05Sep70	1400	2004	2142	Agric.	0	9	6	1	1
	GJCJ	05Sep70	0900	1552	1810	Agric.	0	9	6	1	1
	GJCJ	24Aug70	1630	2143	2323	Agric.	0	9	6	1	1
	GJCJ	24Aug70	1100	1702	1834	Agric.	0	9	6	1	1
Vigo County											
CB Flight Line 217	GJCK-277	05Oct71	1230	1613	1740	Agric.	0	8	3	0	1
	GJCK-277	24Sep71	[illegible]	1911	2014	Agric.	0	8	3	0	1
	GJCK-277	15Sep71	1130	1546	1640	Agric.	0	8	3	0	1
	GJCK-277	28Aug71	1000	1509	1616	Agric.	0	8	3	0	1
	GJCK-277	26Aug71	1130	1601	1750	Agric.	0	8	3	1	1
	GJCK-277	12Aug71	1130	1442	1530	Agric.	0	8	3	0	1
	GJCK-277	05Aug71	1300	1600	1735	Agric.	0	8	3	0	1
	GJCK-277	29Jul71	1130	1604	1730	Agric.	1	8	5	1	1
	GJCK-277	27Jul71	1130	1831	2012	Agric.	0	8	3	0	1
	GJCK-277	21Jul71	1130	1421	1806	Agric.	0	8	3	0	1
	GJCK-277	29Jun71	1130	1609	1758	Agric.	0	8	3	0	1
	GJCK-277	21May71	1130	1639	1746	Agric.	0	9	6	1	1

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(3) For list of organizational addresses, see Appendix C.

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Vermillion County											
Cayuga	GJCK	04May73	0930	1554	1925	Multi	0	8	3	0	1
	GJCK	17Oct72	1000	1647	1758	Multi	0	8	3	0	1
	GJCK	09Aug72	0830	1632	1802	Multi	0	8	3	0	1
	GJCK	13Aug70	1430	1831	2044	Multi	0	9	6	1	1
	GJCK	01Jul70	0930	1344	1710	Agric.	0	9	6	1	1
	GJCK	06May70	1300	1905	2104	Agric.	0	9	6	1	1
Warren County											
CB Flight Line 210	(See Tippecanoe County)										
Tab	GJCL	13Aug70	1430	1831	2040	Agric.	0	9	6	1	1
	GJCL	01Jul70	0930	1344	1710	Agric.	0	9	6	1	1
Warrick County											
CB Flight Line 227	(See Spencer County)										
CB Flight Line 229	GJCJ-277	06Oct71	0900	1653	1834	Agric.	0	8	3	0	1
	GJCJ-277	05Oct71	0900	1751	1855	Agric.	0	8	3	0	1
	GJCJ-277	15Sep71	0900	1749	1850	Agric.	0	8	3	0	1
	GJCJ-277	28Aug71	0900	1724	1847	Agric.	0	8	3	0	1
	GJCJ-277	12Aug71	0900	1650	1834	Agric.	1	8	5	1	1
	GJCJ-277	27Jul71	0900	1700	1807	Agric.	1	8	5	1	1
	GJCJ-277	16Jul71	0900	1723	1824	Agric.	1	8	5	1	1
	GJCJ-277	30Jun71	0900	1614	1727	Agric.	1	8	5	1	1
	GJCJ-277	22May71	1130	1546	1644	Agric.	0	9	6	1	1
Earle	(See Vanderburg County)										
White County											
CB Flight Line 208	GJDL-277	24Sep71	1300	1705	1755	Agric.	0	8	3	0	1
	GJDL-277	14Sep71	1300	1657	1809	Agric.	0	8	3	0	1
	GJDL-277	29Aug71	1300	1632	1733	Agric.	0	8	3	0	1
	GJDL-277	13Aug71	1300	1616	1714	Agric.	0	8	3	0	1
	GJDL-277	31Jul71	1300	1537	1618	Agric.	0	8	3	0	1
	GJDL-277	31Jul71	1130	1515	1530	Agric.	1	8	5	1	1
	GJDL-277	12Jul71	1300	1755	1902	Agric.	0	8	3	0	1
	GJDL-277	28Jun71	1300	1800	1914	Agric.	1	8	5	1	1

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TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
CB Flight Line 208	GJDL-277	17May71	1300	1808	1904	Agric.	0	9	6	1	1
Monon	GJDL	21Aug73	0900	1430	1820	Agric.	0	7	4	0	1
	GJDL	06Jul73	0900	1541	1808	Agric.	0	7	4	0	1
Monticello	GJDL	04May73	0930	1554	1925	Agric.	0	8	3	0	1
	GJDL	17Oct72	1000	1647	1758	Agric.	0	8	3	0	1
	GJDL	10Aug72	1030	1550	1731	Agric.	0	8	3	0	1
Whitley County											
Huntington	(See Huntington)										
KANSAS											
Wyandotte County											
Kansas City	FJKJ,KK,LK	04Apr70	1400	2000	2227	Multi	0	9	6	1	1
	FJKJ,KK,LK	26Mar70	2300	0510	0654	Multi	0	0	2	1	1
MICHIGAN											
Allegan County											
SE Shore Lake Michigan	GJDM,N,P,Q	24Apr74	1030	1609	1901	Hydrology	1	8	2	0	1
	GJDN	13Sep73	1200	1708	1806	Hydrology	1	7	3	0	1
	GJDM,N,P	11Jun73	1000	1542	1641	Hydrology	1	7	3	0	1
	GJDM,N,P	25Jan73	0900	1600	1653	Hydrology	1	7	3	0	1
	GJDM,N,P	28Aug72	0830	1537	1637	Hydrology	1	7	3	0	1
	GJDM,N,P	28May71	1600	2045	2240	Hydrology	1	9	3	0	2
	GJDM,N,P	28May71	0900	1510	1709	Hydrology	1	9	3	0	2
	GJDM,N,P	07May71	0900	1728	1921	Hydrology	1	9	3	0	2
	GJDM,N,P	30Apr71	1330	1837	1904	Hydrology	1	9	3	0	2
	GJDM,N,P	30Apr71	0800	1410	1621	Hydrology	1	9	3	0	2
	GJDM,N,P	23Apr71	1700	2214	2326	Hydrology	1	9	3	0	2
	GJDM,N,P	23Apr71	1330	1841	1931	Hydrology	1	9	3	0	2
	GJDM,N,P	23Apr71	0900	1436	1617	Hydrology	1	9	3	0	2

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
SE Shore Lake Michigan	GJDM,N,P	22Apr71	1830	2339	0027	Hydrology	1	0	0	0	2
	GJDM,N,P	22Apr71	1430	1959	2109	Hydrology	1	9	3	0	2
	GJDM,N,P	22Apr71	0800	1435	1636	Hydrology	1	9	3	0	2
	GJDP	09Sep70	0900	1455	2037	Hydrology	0	9	3	0	4
	GJDM,N,P	07May70	1400	2159	2252	Hydrology	0	9	3	1	3
	GJDM,N,P	11Aug69	0930	1531	1722	Hydrology	1	7	2	1	1
	GJDP	27May69	1330	1954	2010	Hydrology	0	9	6	1	1
	GJDM	26Sep68	1400	1932	2105	Hydrology	0	7	6	1	1
Arenac County											
Saginaw Bay	GJGP,Q	07Apr74	0930	1417	1649	Hydrology	1	8	2	0	1
	GJGP	13Apr73	1300	1828	2044	Hydrology	1	7	3	0	1
	GJGP	20Mar73	1030	1651	1747	Hydrology	1	7	5	0	1
	GJGP	12Jan73	1400	1934	2022	Hydrology	1	7	3	0	1
	GJGP	10Jan73	0900	1445	1640	Hydrology	1	7	3	0	1
	GJGP,Q	29Aug72	1400	1928	2151	Hydrology	1	7	3	0	1
	GJGP	09Sep70	0900	1455	2037	Hydrology	0	9	3	0	4
Bay County											
Saginaw Bay	(See Arenac County)										
Berrien County											
SE Shore Lake Michigan	(See Allegan County)										
Charlevoix County											
Charlevoix	GKEA	08May74	0930	1516	1606	Hydrology	1	8	2	0	1
	GKEA	09Sep70	0900	1455	2037	Hydrology	0	9	3	0	4
Eaton County											
Charlotte	GJFN-279	08Jun73	0930	1426	1626	Agric.	1	7	4	0	1
	GJFN-279	25Aug72	1000	1435	1727	Agric.	0	7	4	0	1
	GJFN-279	13Aug72	0930	1413	1459	Agric.	0	7	4	0	1
	GJFN-279	04Aug72	0930	1521	1621	Agric.	0	6	4	0	1
Genesee County											
Lakes Study	GJGN	22Aug73	0830	1350	1445	Hydrology	0	7	4	0	1
	GJGN	03Jul73	1030	1506	1610	Hydrology	1	7	3	0	1
	GJGN	22Jun73	0930	1353	1439	Hydrology	1	7	3	0	1

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(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Lakes Study	GJGN	31May73	0930	1420	1519	Hydrology	1	7	3	0	1
	GJGN	05Sep72	0900	1614	1646	Hydrology	1	7	3	0	1
	GJGN	30Aug72	1030	1545	1643	Hydrology	1	7	3	0	1
Vienna Township	GJGP	14Jun73	0500	1004	1052	Land Use	1	7	3	0	1
	GJGP	07Jun73	0930	1338	1417	Land Use	1	7	3	0	1
	GJGP	31May73	0930	1530	1628	Land Use	1	7	3	0	1
	GJGP	30Aug72	1030	1655	1752	Land Use	1	7	3	0	1
Gladwin County											
Tittabawassee	GJFP	13Apr73	1300	1828	2044	Hydrology	1	7	3	0	1
	GJFP	12Jan73	1400	1934	2022	Hydrology	1	7	3	0	1
Huron County											
Saginaw Bay	(See Arenac County)										
Port Huron-Port Austin	GJHP,Q	10Apr74	1000	1427	1739	Hydrology	1	8	2	0	1
	GJHP,Q	29Aug72	1400	1928	2151	Hydrology	1	7	3	0	1
Ingham County											
East Lansing/MSU Agric. Farm	GJFN	08Jun73	0930	1426	1626	Agric.	1	7	4	0	1
	GJFN	19Oct72	0930	1455	1531	Multi	1	6	3	0	2
	GJFN	14Sep72	1300	1802	1816	Multi	0	7	4	0	1
	GJFN	25Aug72	1000	1435	1727	Multi	0	7	4	0	1
	GJFN	21Sep71	1400	1637	1651	Agric.	0	8	3	0	1
	GJFN	17Aug71	1400	2028	2100	Agric.	0	8	3	0	1
	GJFN	06Aug71	1400	1926	2029	Agric.	1	8	5	1	1
	GJFN	06Aug71	0900	1426	1746	Agric.	1	8	5	1	1
	GJFN	07Jul71	1400	2107	2132	Agric.	1	8	5	1	1
	GJFN	22May71	1500	1953	2014	Agric.	0	9	6	1	1
Jackson County											
Sharonville	GJFN	05Jun72	1000	1506	1659	Forestry	1	6	4	0	1
	GJFN	16Oct70	0900	1445	1516	Forestry	0	9	3	0	3
	GJFN	01Oct70	1000	1335	1713	Forestry	0	9	6	0	3
	GJFN	29Sep70	0600	1146	1312	Forestry	0	9	6	0	3
	GJFN	06Aug70	0130	0657	0831	Forestry	0	0	0	1	3
	GJFN	05Aug70	1000	1525	1705	Forestry	0	9	6	1	1

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(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Sharonville	GJFN	07Jul70	0900	n/a	n/a	Forestry	0	9	6	1	1
	GJFN	06Jul70	1400	1836	2019	Forestry	0	9	6	1	1
	GJFN	08Jun70	0700	1729	1855	Forestry	1	9	6	0	1
	GJFN	26Nov69	1000	1530	1642	Forestry	0	7	6	1	1
	GJFN	13Aug69	2100	0229	0314	Forestry	0	0	0	1	1
	GJFN	13Aug69	0900	1433	1500	Forestry	0	7	5	1	1
	GJFN	04Aug69	0930	1558	1738	Forestry	0	7	5	1	1
Lapeer County											
Imlay City	GJHN	28Aug73	1330	1807	1901	Land Use	0	7	4	0	1
	GJHN	31May73	0930	1645	1800	Land Use	1	7	3	0	1
	GJHN	24May73	1000	1454	1550	Land Use	1	7	2	0	1
	GJHN	11Apr73	1100	1911	1928	Land Use	1	7	3	0	1
Lenawee County											
Lenawee County	GJGM,N	06Sep73	1000	1438	1600	Agric.	0	6	5	0	1
	GJFM,FN,GM,GN-279	04Aug73	0930	1327	1601	Agric.	0	6	5	0	1
	GJGM	21Aug70	1030	1608	1747	Agric.	1	9	6	0	1
	GJGM	21Aug70	0730	1307	1430	Agric.	1	9	6	0	1
	GJGM	20Jun70	1030	1533	1628	Agric.	1	9	6	0	1
	GJGM	20Jun70	0730	1300	1416	Agric.	1	9	6	0	1
Livingston County											
Brighton	GJGN	08Jun73	0930	1426	1626	Agric.	1	7	4	0	1
	GJGN	19Oct72	0930	1455	1531	Multi	1	6	3	0	2
	GJGN	25Aug72	1000	1435	1727	Multi	0	7	4	0	1
Macomb County											
Imlay City	(See Lapeer County)										
St. Clair River/Lake St. Clair	GJHN	10Apr74	1000	1427	1739	Hydrology	1	8	2	0	1
	GJHN	13Apr73	1300	1828	2044	Hydrology	1	7	3	0	1
	GJHN	12Jan73	1400	1934	2022	Hydrology	1	7	3	0	1
	GJHN	10Jan73	0900	1445	1640	Hydrology	1	7	3	0	1
	GJHN	29Aug72	1400	1928	2151	Hydrology	1	7	3	0	1
	GJHN	06Jul67	1000	1605	1827	Hydrology	1	9	3	1	1
Manistee County											

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(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Dublin	GJEQ	07Sep73	1345	1930	1952	Forestry	1	7	2	0	1
	GJEQ	14Sep72	1300	1909	1959	Forestry	0	7	4	0	1
Monroe County											
Dundee	GJGN	01Oct70	1000	1535	1713	Land Use	0	9	6	0	3
	GJGN	22Jul70	0700	1245	1333	Land Use	0	9	3	2	2
	GJGN	21Jul70	1530	2050	2147	Land Use	0	9	3	2	2
	GJGN	13Jul70	1300	1900	2040	Land Use	0	9	3	2	1
	GJGN	06Jul70	1400	1836	2019	Land Use	0	9	6	1	1
West Shore, Lake Erie	GJGM,N	10Apr74	1000	1427	1739	Hydrology	1	8	2	0	1
	GJGM	11Apr73	0830	1400	1441	Hydrology	1	8	2	0	1
	GJGM,N	23Mar73	0930	1526	1614	Hydrology	0	7	4	0	1
	GJGM,N	29Aug72	1400	1928	2151	Hydrology	1	7	3	0	1
	GJGM,N	29Aug72	0830	1401	1542	Hydrology	0	7	4	0	1
	GJGM,N	05May72	1000	1647	1836	Hydrology	0	8	3	0	1
	GJGM	09Sep70	0900	1455	2037	Hydrology	0	9	3	0	4
	GJGM	26Nov69	1000	1530	1642	Hydrology	0	7	6	1	1
	GJGM	20Nov69	1000	1610	1723	Hydrology	0	9	5	0	1
	GJGM,N	13Aug69	2100	0427	0505	Hydrology	0	0	0	2	1
	GJGM,N	13Aug69	0900	1620	1658	Hydrology	0	9	5	1	1
	GJGM,N	06Jul67	1000	1605	1827	Hydrology	1	9	3	1	1
	GJGM,N	15Dec66	1330	1857	2005	Hydrology	1	0	0	1	1
	GJGM,N	18Nov66	1300	1935	2040	Hydrology	1	9	3	1	1
	GJGM,N	14Nov66	1330	1940	2027	Hydrology	1	9	4	1	1
	GJGM	29Apr66	1300	n/a	n/a	Hydrology	1	9	5	2	1
Muskegon County											
SE Shore Lake Michigan	(See Allegan County)										
Ottawa County											
SE Shore Lake Michigan	(See Allegan County)										
St. Clair County											
Port Huron-Port Austin	(See Huron County)										
St. Clair River/Lake St. Clair	(See Macomb County)										
Sanilac County											

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Port Huron-Port Austin	(See Huron County)										
Tuscola County											
Saginaw Bay	(See Huron County)										
Van Buren County											
SE Shore Lake Michigan	(See Allegan County)										
Washtenaw County											
Ann Arbor	GJGN-190	20Nov73	1100	1912	1923	Multi	1	8	2	0	1
	GJGN-190	05Jun72	1000	1506	1659	Forestry	1	6	4	0	1
	GJGN-190	05May72	1000	1647	1836	Land Use	0	8	3	0	1
	GJGN-190	28Oct71	0930	1652	1733	Multi	0	8	3	0	1
	GJGN-190	15Sep71	1645	2300	2301	Land Use	0	8	1	0	2
	GJGN-190	16Oct70	0900	1445	1516	Forestry	0	9	3	0	3
	GJGN-190	16Oct70	0300	0817	0841	Forestry	0	0	0	0	4
	GJGN-190	05Mar70	1100	1701	1823	Multi	0	8	6	1	1
	GJGN-190	12May69	0945	1515	1532	Multi	0	7	5	1	1
	GJGN-190	21Oct68	1030	1600	1717	Multi	0	7	6	1	1
	GJGN-190	09Sep68	1330	2022	2112	Multi	0	7	6	1	1
	GJGN-190	22May68	1000	1646	1815	Multi	0	7	6	1	1
	GJGN-190	08Nov67	1000	1600	1650	Multi	0	7	6	0	0
	GJGN-190	27Jun67	1300	1847	1948	Multi	1	9	3	1	1
	GJGN-190	15Mar67	1000	1520	1715	Multi	1	9	3	0	1
	GJGN-190	15Dec66	1330	1857	2005	Multi	1	0	0	1	1
	GJGN-190	18Nov66	1300	1935	2040	Multi	1	9	3	1	1
	GJGN	14Nov66	1330	1940	2027	Multi	1	9	4	1	1
	GJGN	28Apr66	1000	n/a	n/a	Multi	1	9	5	2	1
	GJGN	21Mar66	1400	n/a	n/a	Multi	1	1	3	0	0
	GJGN	14Mar66	1000	[illegible]	n/a	Multi	1	0	1	1	1
	GJGN	11Mar66	1000	[illegible]	n/a	Multi	1	0	1	1	1
	GJGN	02Feb66	1400	[illegible]	1949	Multi	0	0	1	1	1
	GJGN	06Jan66	1000	n/a	n/a	Multi	0	0	1	1	1
Ford Lake	GJGN	14Mar74	1700	2225	2312	Hydrology	1	9	1	0	1
	GJGN	24May73	1000	1454	1550	Hydrology	1	7	2	0	1

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(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Ford Lake	GJGN	13Sep72	1300	1849	1859	Hydrology	0	7	4	0	1
	GJGN	04May72	1330	2102	2153	Hydrology	0	7	4	0	1
	GJGN	28Oct71	0930	1652	1733	Hydrology	0	8	3	0	1
	GJGN	04Aug69	0930	1558	1738	Hydrology	0	7	5	1	1
	GJGN	26Sep68	1400	1932	2105	Hydrology	0	7	6	1	1
	GJGN	23Aug67	1300	1938	2116	Hydrology	1	9	6	1	1
	GJGN	15Dec66	1330	1857	2006	Hydrology	1	0	0	1	1
	GJGN	28Apr66	1000	n/a	n/a	Hydrology	1	9	5	2	1
	GJGN	02Feb66	1400	1912	1949	Hydrology	0	0	1	1	1
	GJGN	06Jan66	1000	n/a	n/a	Hydrology	0	0	1	1	1
George Reserve	GJGN	04May72	1330	2102	2153	Forestry	0	7	4	0	1
	GJGN	28Oct71	0930	1652	1733	Forestry	0	8	3	0	1
Milan	GJGN	22Aug68	1000	1548	2023	Land Use	0	7	6	1	1
	GJGN	25Jul68	0900	1513	1624	Land Use	0	7	6	1	1
	GJGN	26Aug66	1000	1837	1919	Land Use	1	9	5	2	1
	GJGN	21Jul66	1200	1819	n/a	Land Use	1	9	5	2	1
	GJGN	24Jun66	1100	1630	1658	Land Use	1	0	2	2	1
	GJGN	04May66	1000	n/a	n/a	Agric.	1	0	2	2	1
Saginaw Forest	GJGN	20Mar73	1030	1810	1834	Forestry	0	7	4	0	1
	GJGN	16Oct70	0900	1445	1516	Forestry	0	9	3	0	3
	GJGN	16Oct70	0300	0817	0841	Forestry	0	0	0	0	4
	GJGN	01Oct70	1000	1535	1713	Forestry	0	9	6	0	3
	GJGN	29Sep70	0600	1146	1312	Forestry	0	9	6	0	3
	GJGN	06Jul70	1400	1836	2019	Forestry	0	9	6	1	1
	GJGN	26Nov69	1000	1530	1642	Forestry	0	7	6	1	1
	GJGN	13Aug69	2100	0229	0314	Forestry	0	0	0	1	1
	GJGN	13Aug69	0900	1433	1500	Forestry	0	7	5	1	1
	GJGN	04Aug69	0930	1558	1738	Forestry	0	7	5	1	1
	GJGN	03Mar67	1000	1520	1717	Forestry	1	9	3	0	1
	GJGN	28Apr66	1000	n/a	n/a	Forestry	1	9	5	2	1
Stinchfield Woods	GJGN	05Jun72	1000	1506	1659	Forestry	1	6	4	0	1
	GJGN	16Oct70	0900	1445	1516	Forestry	0	9	3	0	3

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(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Stinchfield Woods	GJGN	16Oct70	0600	1121	1123	Forestry	0	2	0	0	4
	GJGN	16Oct70	0300	0817	0841	Forestry	0	0	0	0	4
	GJGN	16Oct70	0100	0525	0539	Forestry	0	0	0	0	3
	GJGN	01Oct70	1000	1535	1713	Forestry	0	9	6	0	3
	GJGN	29Sep70	0600	1146	1312	Forestry	0	9	6	0	3
	GJGN	06Aug70	0130	0657	0831	Forestry	0	0	0	1	3
	GJGN	05Aug70	1000	1525	1705	Forestry	0	9	6	1	1
	GJGN	07Jul70	0900	n/a	n/a	Forestry	0	9	6	1	1
	GJGN	06Jul70	1400	1836	2019	Forestry	0	9	6	1	1
	GJGN	08Jun70	0700	1729	1855	Forestry	1	9	6	0	1
	GJGN	26Nov69	1000	1530	1642	Forestry	0	7	6	1	1
	GJGN	13Aug69	2100	0229	0314	Forestry	0	0	0	1	1
	GJGN	13Aug69	0900	1433	1500	Forestry	0	7	5	1	1
	GJGN	04Aug69	0930	1558	1738	Forestry	0	7	5	1	1
	GJGN	28Apr66	1000	n/a	n/a	Forestry	1	9	5	2	1
U of M Botanical Gardens	GJGN	05Jun72	1000	1506	1659	Forestry	1	6	4	0	1
	GJGN	01Oct70	1000	1535	1713	Forestry	0	9	6	0	3
	GJGN	22Nov66	1400	1935	2025	Forestry	1	9	3	1	1
Whitmore Lake	GJGN	15Nov66	1330	1857	2005	Multi	1	0	0	1	1
	GJGN	21Jul66	1200	1819	n/a	Multi	1	9	5	2	1
	GJGN	28Apr66	1000	n/a	n/a	Multi	1	9	5	2	1
	GJGN	02Feb66	1400	1912	1949	Multi	0	0	1	1	1
	GJGN	06Jan66	1000	n/a	n/a	Multi	0	0	1	1	1
Whittaker	GJGN	30Aug66	1000	1535	1641	Multi	1	9	5	2	1
	GJGN	25Aug66	1000	1837	1919	Multi	[illegible]	9	5	2	1
	GJGN	21Jul66	1200	1819	n/a	Multi	[illegible]	9	5	2	1
	GJGN	24Jun66	1100	1630	1658	Multi	1	0	2	2	1
Ypsilanti	GJGN	26Feb69	1100	1610	1650	Multi	0	7	5	1	1
	GJGN	22Aug68	1000	1548	2023	Multi	0	7	6	1	1
	GJGN	25Jul68	0900	1513	1624	Multi	0	7	6	1	1
	GJGN	22May68	1000	1646	1815	Multi	0	7	6	1	1
Wayne County											

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Belleville Lake	GJGN	20Nov73	1100	1912	1923	Hydrology	1	8	2	0	1
	GJGN	13Sep72	1300	1849	1859	Hydrology	0	7	4	0	1
Detroit River	GJGN	10Apr74	1000	1427	1739	Hydrology	1	8	2	0	1
	GJGN	14Mar74	1700	2225	2312	Hydrology	1	9	1	0	1
	GJGN	13Apr73	1300	1828	2044	Hydrology	1	7	3	0	1
	GJGN	23Mar73	0930	1526	1614	Hydrology	0	7	4	0	1
	GJGN	12Jan73	1400	1934	2022	Hydrology	1	7	3	0	1
	GJGN	10Jan73	0900	1445	1640	Hydrology	1	7	3	0	1
	GJGN	29Aug72	1400	1928	2151	Hydrology	1	7	3	0	1
	GJGN	13Jul70	1300	1900	2040	Land Use	0	9	3	2	1
	GJGN	05Mar70	1100	1701	1823	Hydrology	0	8	6	1	1
	GJGN	26Nov69	1000	1530	1642	Hydrology	0	7	6	1	1
	GJGN	20Nov69	1000	1610	1723	Hydrology	0	9	5	0	1
	GJGN	13Aug69	2100	0427	0505	Hydrology	0	0	0	2	1
	GJGN	13Aug69	0900	1620	1658	Hydrology	0	9	5	1	1
	GJGN	22Aug68	1450	2014	2023	Hydrology	0	7	5	1	0
	GJGN	06Jul67	1000	1605	1827	Hydrology	1	9	3	1	1
	GJGN	15Dec66	1330	1857	2005	Hydrology	1	0	0	1	1
	GJGN	14Nov66	1330	1940	2027	Hydrology	1	9	4	1	1
St. Clair River/Lake St. Clair	(See Macomb County)										
Willow Run Airport	GJGN	02Oct74	1000	1455	1609	Multi	1	9	1	0	1
	GJGN	14Mar74	1700	2225	2312	Multi	1	9	1	0	1
	GJGN	20Nov73	1100	1912	1923	Multi	1	8	2	0	1
	GJGN	06Sep73	1000	1438	1600	Multi	0	6	5	0	1
	GJGN	02Aug73	1500	1946	1958	Multi	0	6	5	0	1
	GJGN	25Jun73	1015	1449	1524	Multi	0	7	4	0	1
	GJGN	24May73	1000	1454	1550	Multi	1	7	2	0	1
	GJGN	05Jun72	1000	1506	1659	Multi	1	6	4	0	1
	GJGN	04May72	1330	2102	2153	Multi	0	7	4	0	1
	GJGN	28Oct71	0930	1652	1733	Multi	0	8	3	0	1
	GJGN	21Apr71	1400	1922	2002	Multi	1	9	3	0	1
	GJGN	13Jul70	1300	1900	2040	Multi	0	9	3	2	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Willow Run Airport	GJGN	20Nov69	1000	1610	1723	Multi	0	9	5	0	1
	GJGN	03Sep69	1100	1625	1738	Multi	0	7	5	1	1
	GJGN	03Sep69	0715	1321	1520	Multi	0	7	5	1	1
	GJGN	04Aug69	0930	1558	1738	Multi	0	7	5	1	1
	GJGN	12May69	0945	1515	1532	Multi	0	7	5	1	1
	GJGN	26Feb69	1100	1610	1650	Multi	0	7	5	1	1
	GJGN	09Sep68	1330	2022	2112	Multi	0	7	6	1	1
	GJGN	22Aug68	1000	1548	2023	Multi	0	7	6	1	1
	GJGN	25Jul68	0900	1513	1624	Multi	0	7	6	1	1
	GJGN	22May68	1000	1646	1815	Multi	0	7	6	1	1
	GJGN	08Nov67	1000	1600	1650	Multi	0	7	6	0	0
	GJGN	23Aug67	1300	1938	2116	Multi	1	9	6	1	1
	GJGN	27Jun67	1300	1847	1948	Multi	1	9	3	1	1
	GJGN	15Mar67	1000	1520	1715	Multi	1	9	3	0	1
	GJGN	14Mar67	1000	1637	1735	Multi	1	9	3	0	1
	GJGN	02Mar67	1000	1710	1848	Multi	1	9	3	0	1
	GJGN	15Dec66	1330	1857	2005	Multi	1	0	0	1	1
	GJGN	22Nov66	1400	1935	2025	Multi	1	9	3	1	1
	GJGN	18Nov66	1300	1935	2040	Multi	1	9	3	1	1
	GJGN	14Nov66	1330	1940	2027	Multi	1	9	4	1	1
	GJGN	01Sep66	1300	1901	1940	Forestry	1	9	5	2	1
	GJGN	30Aug66	1000	1535	1641	Multi	1	9	5	2	1
	GJGN	25Aug66	1000	1837	1919	Multi	1	9	5	2	1
	GJGN	21Jul66	1200	1819	n/a	Multi	1	9	5	2	1
	GJGN	24Jun66	1100	1630	1658	Multi	1	0	2	2	1
	GJGN	28Apr66	1000	n/a	n/a	Multi	1	9	5	2	1
	GJGN	21Mar66	1400	1930	n/a	Multi	1	1	3	0	0
	GJGN	14Mar66	1000	n/a	n/a	Multi	1	0	1	1	1
	GJGN	11Mar66	1000	n/a	n/a	Multi	1	0	1	1	1
	GJGN	02Feb66	1400	1912	1949	Multi	0	0	1	1	1
	GJGN	06Jan66	1000	n/a	n/a	Multi	0	0	1	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

Sheet 27 of 32 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
NEW YORK											
Monroe County											
S Shore Lake Ontario	GJLP,MP,NP	25Mar73	1000	1530	1620	Hydrology	1	8	2	0	1
	GJLP,MP,NP	31Jul72	1400	2043	2238	Hydrology	1	8	2	0	1
	GJLP,MP,NP	20Jun72	0845	1331	1452	Hydrology	1	8	2	0	1
	GJLP,MP,NP	18Jun72	0400	0918	1031	Hydrology	0	0	2	0	2
Nassau County											
New York Bay	HJAL,BL-188	07Apr73	1300	1841	2044	Hydrology	1	8	2	0	1
	HJAL,BL-188	07Apr73	0800	1331	1543	Hydrology	1	8	2	0	1
	HJBL-188	06Apr73	1300	1837	1910	Hydrology	1	8	2	0	1
	HJBL-188	16Aug72	0900	1420	1447	Hydrology	1	8	2	0	1
Niagara County											
S Shore Lake Ontario	(See Monroe County)										
Orleans County											
S Shore Lake Ontario	(See Monroe County)										
Oswego County											
S Shore Lake Ontario	(See Monroe County)										
Wayne County											
S Shore Lake Ontario	(See Monroe County)										
NORTH DAKOTA											
Foster County											
Woodworth	FKEC,FB,FC-216	02Aug73	0830	1544	1839	Game Mgt.	0	6	5	0	1
	FKEC,FB,FC-216	12May73	0730	1316	1523	Game Mgt.	1	7	3	0	1
	FKFC,GC-216	28Jul72	1700	2310	2507	Game Mgt.	1	7	4	0	1
	FKFC,GC-216	19May72	0730	1624	1840	Game Mgt.	1	7	4	0	1
	FKFC,GC-216	31Jul70	2330	0609	0708	Game Mgt.	0	0	0	1	3
	FKFC,GC-216	31Jul70	0930	1549	1649	Game Mgt.	0	9	6	1	1
	FKFC,GC-216	23May70	0030	0710	0816	Game Mgt.	0	0	5	1	1
	FKFC,GC-216	22May70	0900	1533	1752	Game Mgt.	0	9	6	1	1
	FKFC,GC-216	21May70	1530	2116	2140	Multi	0	9	6	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 28 of 32 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Woodworth	FKFC,GC-216	31May68	0730	1427	1630	Multi	0	7	6	1	1
Kidder County											
Woodworth	(See Foster County)										
Stutsman County											
Woodworth	(See Foster County)										
Wells County											
Woodworth	(See Foster County)										
OKLAHOMA											
Johnston County											
Mill Creek	FJJE,FJFE,GE-178	30Jun72	0530	1114	1439	Geology	1	6	4	0	6
	FJJE,FJFE,GE-178	28Jun72	1200	1732	2014	Geology	1	6	4	0	4
	FJJE-178	26Jun70	0900	1412	1553	Geology	1	9	3	1	1
	FJJE-178	26Jun70	0500	1023	1142	Geology	0	0	0	1	3
	FJJE-178	25Jun70	0900	1434	1616	Geology	1	9	3	0	2
	FJJE-178	25Jun70	0500	1052	1200	Geology	0	0	0	1	2
	FJJE-178	24Jun70	1500	2041	2220	Geology	1	9	3	0	2
	FJJE-178	24Jun70	1200	1726	1920	Geology	1	9	3	0	2
	FJJE-178	23Jun70	1330	1830	n/a	Geology	1	9	3	0	2
OREGON											
Clatsop County											
Newport to Astoria	DJLQ,DKLA,LB,KA,KB,JA,JB,MA,MB	23Sep69	1330	2157	2416	Oceanog.	1	7	2	1	1
	DJLQ,DKLA,LB,KA,KB,JA,JB,MA,MB	23Sep69	0900	1715	1810	Oceanog.	1	7	2	1	1
	DJLQ,DKLA,LB,KA,KB,JA,JB,MA,MB	08Jul69	1130	2117	0006	Oceanog.	0	6	4	1	2
Coos County											
Brookings to Coos Bay	DJHP,JP,KP,LP,DJHN,JN,KN,LN	21Sep69	1000	1855	2059	Oceanog.	1	7	2	1	1
	DJHP,JP,KP,LP,DJHN,JN,KN,LN	15Sep69	1045	1906	2104	Oceanog.	1	7	4	1	1
	DJHP,JP,KP,LP,DJHN,JN,KN,LN	03Jul69	1400	2253	0200	Oceanog.	0	6	4	1	2
Curry County											

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
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(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS (Continued)

Sheet 29 of 32 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Brookings to Coos Bay	(See Coos County)										
Douglas County											
Northland to Newport	DJHQ,HP,JQ,JP,KQ,KP,LQ,LP	24Sep69	1300	2123	2418	Oceanog.	1	6	2	1	1
	DJHQ,HP,JQ,JP,KQ,KP,LQ,LP	15Sep69	1500	2332	0130	Oceanog.	1	7	2	1	1
	DJHQ,HP,JQ,JP,KQ,KP,LQ,LP	14Sep69	0900	1815	2030	Oceanog.	1	6	4	1	1
	DJHQ,HP,JQ,JP,KQ,KP,LQ,LP	06Jul69	1130	2021	2321	Oceanog.	0	6	4	1	1
Lane County											
Northland to Newport	(See Douglas County)										
Lincoln County											
Newport to Astoria	(See Clatsop County)										
Northland to Newport	(See Douglas County)										
Tillamook County											
Newport to Astoria	(See Clatsop County)										
SOUTH DAKOTA											
Lawrence County											
Deadwood	FJBQ-149	25May72	1130	1659	1740	Forestry	0	6	5	0	1
	FJBQ-149	25May72	0745	1425	1515	Forestry	0	6	5	0	1
	FJBQ-149	24May72	0830	1524	1525	Forestry	0	6	5	0	1
	FJBQ-149	22Jul69	0830	1506	1614	Forestry	0	7	5	1	1
	FJBQ-149	22Jul69	1230	1903	1956	Forestry	0	7	5	1	1
	FJBQ-149	21Jul69	1430	2059	2255	Forestry	0	7	5	1	1
	FJBQ-149	21Jul69	1030	1723	1921	Forestry	0	7	5	1	1
	FJBQ-149	30May68	0730	1407	1458	Forestry	0	7	6	1	1
	FJBQ-149	29May68	1400	1951	2035	Forestry	0	7	6	1	1
	FJBQ-149	29May68	1130	1806	1855	Forestry	0	7	6	1	1
	FJBQ-149	29May68	0830	1524	1614	Forestry	0	7	6	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
TENNESSEE											
Blount County											
Tennessee Valley	GJFF,FG,GF	11Mar71	0900	1508	1727	Multi	0	9	6	1	1
	GJFF,FG,GF	23Sep70	1100	1647	1705	Multi	0	9	6	1	1
Loudon County											
Tennessee Valley	(See Blount County)										
Monroe County											
Tennessee Valley	(See Blount County)										
TEXAS											
Harris & Chambers Counties											
Houston Area	FHKQ-175	12Nov71	1000	1655	1823	Multi	0	8	3	0	1
	FHKQ-175	11Nov71	1300	1915	2050	Multi	0	8	3	0	1
	FHKQ-175	11Nov71	1000	1603	1753	Multi	0	8	3	0	1
	FHKQ-175	09Mar71	0400	1855	2049	Multi	0	0	0	0	2
	FHKQ-175	09Mar71	0000	0622	0713	Multi	0	0	0	0	2
	FHKQ-175	08Mar71	2000	0241	0341	Multi	0	0	0	0	2
	FHKQ-175	08Mar71	1600	2208	2321	Multi	1	9	3	0	1
	FHKQ-175	08Mar71	1200	1652	1940	Multi	1	9	3	0	1
	FHKQ-175	08Mar71	0800	1442	1552	Multi	1	9	3	0	1
Hidalgo County											
San Manuel	FHHM	04Mar71	0550	1219	1301	Agric.	0	0	1	1	2
	FHHM	03Mar71	0550	1238	1343	Agric.	0	9	3	1	2
	FHHM	27Feb71	1300	2018	2119	Agric.	0	9	6	0	2
	FHHM	02Jun66	1000	1858	1900	Agric.	1	9	5	2	1
	FHHM	01Jun66	1800	0031	0113	Agric.	1	9	5	2	1
	FHHM	01Jun66	1330	1932	2015	Agric.	1	9	5	2	1
	FHHM	01Jun66	0500	1135	1213	Agric.	0	0	2	2	1
	FHHM	30May66	1430	2103	2143	Agric.	1	9	5	2	1
Weslaco	FHHM-032	04Mar71	0550	1219	1301	Agric.	0	0	1	1	2
	FHHM-032	03Mar71	0550	1238	1343	Agric.	0	9	3	1	2

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
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(3) For list of organizational addresses, see Appendix C.

TABLE 2. SITES WITH MULTIPLE CALENDAR COVERAGE AT OPTICAL WAVELENGTHS
(Continued)

Sheet 31 of 32 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Weslaco	FHHM-032	27Feb71	1300	2018	2119	Agric.	0	9	6	0	2
	FHHM-032	02Jun66	1000	1834	1241	Agric.	1	9	5	2	1
	FHHM-032	01Jun66	1800	0005	0019	Agric.	1	9	5	2	1
	FHHM-032	01Jun66	1330	1932	2015	Agric.	1	9	5	2	1
	FHHM-032	01Jun66	0500	1135	1213	Agric.	0	0	2	2	1
	FHHM-032	31May66	1000	n/a	n/a	Agric.	1	9	5	2	1
	FHHM-032	30May66	1430	2103	2143	Agric.	1	9	5	2	1
Willacy County											
Raymondville	FHHM	04Mar71	0550	1219	1301	Agric.	0	0	1	1	2
	FHHM	03Mar71	0550	1238	1343	Agric.	0	9	3	1	2
	FHHM	27Feb71	1300	2018	2119	Agric.	0	9	6	0	2
	FHHM	02Jun66	1000	1834	1241	Agric.	1	9	5	2	1
	FHHM	01Jun66	1800	0005	0019	Agric.	1	9	5	2	1
	FHHM	31May66	1000	n/a	n/a	Agric.	1	9	5	2	1
VIRGINIA											
Augusta County											
Staunton	GJMJ,MH	15Dec70	1000	1535	1612	Multi	0	9	6	0	1
	GJMJ,MH	14Dec70	2200	0400	0422	Multi	0	0	0	1	3
	GJMJ,MH	08Apr70	1000	1543	1608	Multi	0	9	6	1	1
	GJMJ,MH	07Apr70	2330	0555	0616	Multi	0	0	2	1	1
WASHINGTON											
Grant County											
Moses Lake	EKAB,AC-207	23Oct69	0530	1415	1508	Multi	0	0	0	3	1
	EKAB,AC-207	22Oct69	1900	0235	0357	Multi	0	0	3	1	1
	EKAB,AC-207	22Oct69	1430	2300	2423	Multi	0	7	6	1	1
	EKAB,AC-207	22Oct69	0930	1759	1841	Multi	0	7	6	1	1
	EKAB,AC-207	25Sep69	1000	1946	2047	Multi	0	7	5	1	1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands				
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR
Skamania County											
Wind River	DKPA	26Sep69	1030	1907	1946	Forestry	0	7	5	1	1
	DKPA	26Sep69	0730	1630	1652	Forestry	0	7	5	1	1
	DKPA	15Jul69	1030	1910	1946	Forestry	0	7	5	1	1
	DKPA	15Jul69	0630	1525	1557	Forestry	0	7	5	1	1
	DKPA	14Jul69	1330	2058	2226	Forestry	0	7	5	1	1
	DKPA	14Jul69	0800	1724	1817	Forestry	0	7	5	1	1
CANADA											
Guelph & N Shore Lake Ontario	GJLP-239	11Sep73	0545	1032	1054	Multi	0	0	0	0	1
	GJKP,LP,MP-239	24Mar73	0930	1552	1757	Hydrology	1	8	2	0	1
	GJLP,MP-239	10Sep73	1200	1726	1937	Multi	0	6	5	0	1
	GJKP,MP-239	07Sep72	0830	1438	1558	Hydrology	1	8	2	0	1
	GJLP-239	18Jun72	0400	0918	1031	Hydrology	0	0	2	0	2
	GJLP-239	17Jun72	1200	1625	2103	Hydrology	0	7	4	0	1
	GJLP-239	11May71	1200	1642	1917	Hydrology	0	9	6	0	3
	GJLP-239	11May71	0400	0934	1015	Hydrology	0	0	0	0	3
	GJLP,MP-239	10May71	1330	1934	2138	Hydrology	1	9	3	0	2
	GJLP-239	10May71	0900	1637	1743	Hydrology	1	9	3	0	2

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 3. SITES WITH MSS AND SLAR COVERAGE

Sheet 1 of 3 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands					X		L	
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR	P	C	P	C
CALIFORNIA															
Mono County	EJBH	08Oct71	0715	1415	1740	Geology	-	-	-	-	-	1	1	-	-
	EJBH	05Oct71	0707	1407	1735	Geology	-	-	-	-	-	1	1	1	1
	EJBH	04Oct71	1018	1718	2035	Geology	-	-	-	-	-	-	-	1	1
	EJBH	10Jan69	0635	1435	1815	Geology	-	-	-	-	1	-	-	-	-
	EJBH	23Sep68	0900	1752	1848	Geology	-	8	4	-	-	-	-	-	-
	EJBH	24May66	1000	1936	n/a	Geology	2	10	2	-	1	-	-	-	-
Imperial County	EJDE-002	01Oct72	0500	1217	1313	Geology	-	1	-	-	3	-	-	-	-
	EJDE-002	30Sep72	1200	2102	2222	Geology	1	5	3	-	-	-	-	-	-
	EJDE-002	03Oct71	0732	1432	1800	Geology	-	-	-	-	-	1	1	1	1
	EJDE-002	02Oct71	0650	1350	1715	Geology	-	-	-	-	-	1	1	-	-
	EJDE-002	01Oct71	0957	1657	1924	Geology	-	-	-	-	-	1	1	-	-
	EJDE-002	30Oct70	0730	1603	1645	Geology	1	9	3	-	4	-	-	-	-
	EJDE-002	29Oct70	0800	1713	1756	Geology	1	9	3	-	4	-	-	-	-
GEORGIA															
Oconee County	GJGD	18Apr74	0823	1223	1630	Agric.	-	-	-	-	-	1	1	1	1
	GJGD	17Apr74	0930	1434	1454	Agric.	1	7	3	-	1	-	-	-	-
INDIANA															
Huntington County	GJEL	03Oct73	0254	0754	1122	Agric.	-	-	-	-	-	1	1	1	1
	GJEL	13Sep73	0955	1455	1703	Agric.	-	-	-	-	-	1	1	1	1
	GJEL	21Aug73	0900	1430	1820	Agric.	-	7	4	-	1	-	-	-	-
	GJEL	07Jul73	0815	1346	1500	Agric.	-	7	4	-	1	-	-	-	-
	GJEL	06Jul73	0900	1541	1808	Agric.	-	7	4	-	1	-	-	-	-
KANSAS															
Douglas County	FJKJ	04Apr70	1400	2000	2227	Geology	-	7	6	1	1	-	-	-	-
	FJKJ	26Mar70	2300	0510	0654	Geology	-	-	2	1	1	-	-	-	-

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 2 of 3 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands					X		L	
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR	P	C	P	C
Douglas County	FJKJ	26Sep69	0805	1305	1645	Agric.	-	-	-	-	-	1	1	-	-
	FJKJ	24Sep69	0940	1440	1605	Agric.	-	-	-	-	-	1	1	-	-
MICHIGAN															
Bay County	GJGM,N	03Oct73	0254	1754	1122	Multi	-	-	-	-	-	1	1	1	1
Monroe County	GJGM,N	13Apr73	1300	1828	2044	Multi	1	7	3	-	1	-	-	-	-
Oakland County	GJGM,N	11Apr73	0800	1911	1928	Multi	1	7	3	-	1	-	-	-	-
Wayne County	GJGM,N	05Apr73	0930	1430	1750	Multi	-	-	-	-	-	1	1	1	1
	GJGM,N	28Mar73	1033	1533	1737	Multi	-	-	-	-	-	1	1	1	1
	GJGM,N	12Jan73	1400	1934	2022	Multi	1	7	3	-	1	-	-	-	-
	GJGM,N	10Jan73	0900	1445	1640	Multi	1	7	3	-	1	-	-	-	-
	GJGM,N	05May72	1000	1647	1836	Multi	-	8	3	-	1	-	-	-	-
OKLAHOMA															
Carter County	FJHE	30Jun72	0530	1114	1439	Geology	1	6	4	-	6	-	-	-	-
	FJHE	28Jun72	1200	1732	2014	Geology	1	6	4	-	4	-	-	-	-
	FJHE	26Jun70	0900	1412	1553	Geology	1	9	3	1	1	-	-	-	-
	FJHE	26Jun70	0500	1023	1142	Geology	-	-	-	1	3	-	-	-	-
	FJHE	25Jun70	0900	1434	1616	Geology	1	9	3	-	2	-	-	-	-
	FJHE	25Jun70	0500	1052	1200	Geology	-	-	-	1	2	-	-	-	-
	FJHE	24Jun70	1500	2041	2320	Geology	1	9	3	-	2	-	-	-	-
	FJHE	24Jun70	1200	1726	1920	Geology	1	9	3	-	2	-	-	-	-
	FJHE	23Jun70	1330	1830	n/a	Geology	1	9	3	-	2	-	-	-	-
	FJHE	02Oct69	0745	1245	1535	Geology	-	-	-	-	-	1	1	-	-
	FJHE	01Oct69	0800	1300	1615	Agric.	-	-	-	-	-	1	1	-	-

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 3. SITES WITH MSS AND SLAR COVERAGE
(Continued)

Sheet 3 of 3 Sheets

Site Name	Site Location	Flight Index		Data Acquired: GMT Hr:Min		Major Discipline	No. of Instrument Imagery Bands					X		L	
		Date	Time	Start	Stop		UV	VIS	NIR	MIR	FIR	P	C	P	C
TEXAS															
Harris County (HATS)	FHKQ-175	25Apr72	0825	1425	1550	Multi	-	-	-	-	-	1	-	-	-
	FHKQ-175	23Apr72	0925	1525	1825	Multi	-	-	-	-	-	1	-	-	-
	FHKQ-175	22Apr72	0720	1320	1615	Multi	-	-	-	-	-	1	-	-	-
	FHKQ-175	17Apr72	1050	1650	1825	Multi	-	-	-	-	-	1	-	-	-
	FHKQ-175	12Nov71	1000	1655	1821	Multi	-	7	4	-	1	-	-	-	-
	FHKQ-175	11Nov71	1300	1915	2050	Multi	-	7	4	-	1	-	-	-	-
	FHKQ-175	11Nov71	1000	1603	1753	Multi	-	7	4	-	1	-	-	-	-
	FHKQ-175	09Mar71	0400	1855	2049	Multi	-	-	-	-	2	-	-	-	-
	FHKQ-175	09Mar71	0000	0622	0713	Multi	-	-	-	-	2	-	-	-	-
	FHKQ-175	08Mar71	2000	0241	0341	Multi	-	-	-	-	2	-	-	-	-
	FHKQ-175	08Mar71	1600	2208	2321	Multi	1	9	3	-	1	-	-	-	-
	FHKQ-175	08Mar71	1200	1652	1940	Multi	1	9	3	-	1	-	-	-	-
	FHKQ-175	08Mar71	0800	1442	1552	Multi	1	9	3	-	1	-	-	-	-
	FHKQ-175	04Mar71	1100	1809	1846	Multi	1	9	3	-	1	-	-	-	-

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

3.2 TOTAL LISTING OF EARTH RESOURCES DATA

All of the flights for which ERIM has retrievable earth resources imagery are listed here this section. The sources of the imagery are the M7, M5 and M1A1 optical scanners and the X- and L-band SLAR system. The imagery is listed first for quick reference by missions and then for more detailed reference by individual flight. The missions and flights for each source are grouped separately with both listings in reverse chronological order.

3.2.1 MISSION LISTINGS

The missions for each imagery source are listed by (1) the time period of the flights, (2) the mission title and NASA mission number if one was assigned, (3) major scientific discipline, (4) principal investigator (PI) who made use of the imagery, (5) his organization and (6) data collection contract number and agency. Organizational addresses are found in Appendix C.

The PI and published documents are the sources of the site descriptions and surface conditions and measurements which may be required to support further analysis of the airborne sensor imagery. A reference list of documents which made use of the listed data is presented in Appendix A.

The missions flown with the M7 multispectral scanner system are listed in Table 4. This system became operational in June 1971 and is still available for data collection operations, providing twelve selectable spectral bands in the ultraviolet, visible and infrared wavelengths.

The missions flown with the M5 multispectral scanner system are listed in Table 5. This system, which first became operational in January 1966, was retired from active use in December 1971.

The missions flown with the M1A1 thermal scanner system are listed in Table 6. This system was first operated with magnetic tape recording of imagery in 1968 and was retired in 1971.

The missions flown with the SLAR system are listed in Table 7. This system was first used for earth resources data collection in 1968, and is presently devoted primarily to earth resources mapping. In 1968 it had only a single imagery channel at X-band frequencies. In 1969 a second X-band channel was added to provide both parallel and cross-polarized imagery. In 1971 an either X- or L-band capability was added, with dual polarized recording. In March 1973 the current capability of simultaneous operation in both X- and L-band was achieved.

TABLE 4. M7 MULTISPECTRAL SCANNER MISSIONS

Sheet 1 of 4 Sheets

Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No.
03Oct74	03Oct74	Wabash River, Indiana		Hydrology	S. Luther	LARS, Purdue	8355-01
02Oct74	02Oct7.	Digital Recording	93M	Multi	P. Hasell	ERIM	NAS9-13829
31Jul74	01Aug74	Purdue Power Plants		Hydrology	R. Bailey	LARS, Purdue	7633-01
20May74	21May74	Pricetown, West Virginia		Geol./Mining	W. Overbey	Bu. of Mines, W. Virginia	H0346139
10Apr74	08May74	Michigan Shoreline	92M	Hydrology	D. Lowe	ERIM	NAS9-13829
17Apr74	17Apr74	Oconee County, Georgia	91M	Hydrol/Agric.	T. Davis	NASA/KSC	NAS9-13829
08Apr74	08Apr74	Alma, Michigan		Land Use	R. Maxwell	ERIM	11557(62-7014)74R
03Apr74	03Apr74	Test Flight		Land Use	P. Hasell	ERIM	
20Mar74	20Mar74	Citrus Groves, Florida	89M	Agriculture	T. Davis	NASA/KSC	NAS9-13829
20Mar74	20Mar74	Fort Pierce Inlet, Florida	89M	Hydrology	T. Davis	NASA/KSC	NAS9-13829
19Mar74	19Mar74	Volusia County, Florida	89M	Geol./Soils	T. Davis	NASA/KSC	NAS9-13829
19Mar74	19Mar74	Oklawaha River, Florida		Hydrology	J. Weber	ERIM	
14Mar74	14Mar74	Local Test		Multi	P. Hasell	ERIM	
30Jan74	30Jan74	Wabash R. Basin, Indiana	87M	Land Use	L. Silva	LARS, Purdue	NAS9-13829
20Nov73	20Nov73	Local Test		Multi	P. Hasell	ERIM	
07Sep73	07Sep73	Great Lakes	85M	Atmos.	R. Turner	ERIM	NAS9-9304
13Sep73	13Sep73	Power Plants		Hydrology	S. Zivi	Argonne Natl. Laboratory	P006598-821-3
10Sep73	11Sep73	Lake Ontario	85M	Multi	F. Polcyn	ERIM	NAS9-9304
07Sep73	07Sep73	Michigan Oak Worm	85M	Forestry	A. Andersen	MSU	NAS9-9304
06Sep73	06Sep73	Test Flight		Agriculture	R. Nalepka	ERIM	
28Aug73	28Aug73	M53 Highway, Michigan		Land Use	A. Sellman	ERIM	GI-34809X1
22Aug73	22Aug73	Genesee County Lakes Study		Hydrology	C. Wezernak	ERIM	GI-34809X1
20Aug73	21Aug73	Indiana, Illinois	85M	Agriculture	F. Hall	NASA/JSC	NAS9-9304
12Aug73	12Aug73	Woodworth, North Dakota	85M	Hydrol/Game Mgt.	H. Nelson	N.Prairie Wildlife Res.Center	NAS9-9304
10Aug73	10Aug73	Two Rivers, Wisconsin		Hydrology	S. Zivi	Argonne Natl. Laboratory	P006598-821-3
05Aug73	05Aug73	Southern Michigan	85M	Agriculture	R. Nalepka, F. Thomson, L. Manderscheid	ERIM MSU	NAS9-9304
04Aug73	04Aug73	Lenawee County, Michigan	84M	Agriculture	J. Erickson	ERIM	NAS9-9304
02Aug73	02Aug73	Test Flight		Multi	P. Hasell	ERIM	
05Jul73	07Jul73	Illinois, Indiana	83M	Agriculture	F. Hall	NASA/JSC	NAS9-9304
31May73	03Jul73	Genesee County Lakes Study		Hydrology	C. Wezernak	ERIM	GI-34809X1

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 2 of 4 Sheets

Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No.
25Jun73	25Jun73	Test Flight		Multi	P. Hasell	ERIM	
31May73	14Jun73	Genesee Co., Vienna Twp.		Land Use	E. Jebe	ERIM	GI-34809X1
11Jun73	11Jun73	Lake Michigan		Hydrology	C. Wezernak	ERIM	
10Jun73	10Jun73	Wabash R. Basin, Indiana		Multi	L. Silva	LARS, Purdue	NAS9-9304
08Jun73	08Jun73	Eaton County, Michigan		Agriculture	W. Malila/R. Nalepka	ERIM	NAS9-9304
31May73	31May73	M53 Highway, Michigan		Land Use	A. Sellman	ERIM	NAS9-9304
24May73	24May73	Test Flight		Multi	P. Hasell	ERIM	
12May73	12May73	Woodworth, North Dakota	81M	Hydrol/Game Mgt.	H. Nelson	N.Prairie Wildlife Res.Center	NAS9-9304
04May73	04May73	Wabash R. Basin, Indiana	80M	Multi	D. Landgrebe	LARS, Purdue	NAS9-9304
19Apr73	20Apr73	Chelsea-Norwegian Church, Kansas	79M	Geology	W. Overbey	Bu. of Mines, W. Virginia	NAS9-9304
13Apr73	13Apr73	State of Michigan Water Resources Comm.		Hydrology	C. Wezernak	ERIM	
11Apr73	11Apr73	Imlay City, Michigan		Land Use	A. Sellman	ERIM	NGR-23-005-552
20Mar73	11Apr73	Grand Traverse/Washtenaw County, Michigan	78M	Forestry	J. Erickson	ERIM	NAS9-9304
11Apr73	11Apr73	Monroe, Michigan Flooding		Hydrology	A. Sellman	ERIM	NGR-23-005-552
07Apr73	07Apr73	Lower New York Bay	77M	Oceanog.	D. Clark	NOAA	NAS9-9304
06Apr73	06Apr73	New York Bight	77M	Oceanog.	C. Wezernak	ERIM	NAS9-9304
24Mar73	25Mar73	Lake Ontario	75M	Hydrology	F. Polcyn	ERIM	NAS9-9304
23Mar73	23Mar73	Test Flight		Hydrology	P. Hasell	ERIM	
20Mar73	20Mar73	Test Flight		Hydrology	P. Hasell	ERIM	
10Jan73	25Jan73	State of Michigan Water Resources Comm.		Hydrology	C. Wezernak	ERIM	
02Jan73	02Jan73	Wabash R. Basin, Indiana	87M	Land Use	L. Silva	LARS, Purdue	NAS9-9304
17Nov72	17Nov72	Tampa Bay, Florida	68M	Hydrology	C. Wezernak	ERIM	NAS9-9304
16Nov72	16Nov72	Southeast Florida	68M	Oceanog.	C. Wezernak	ERIM	NAS9-9304
14Sep72	19Oct72	Eaton County, Michigan	65M	Multi	W. Malila, R. Nalepka, A. Andersen	ERIM MSU	NAS9-9304
17Oct72	17Oct72	Wabash R. Basin, Indiana	67M	Multi	D. Landgrebe	LARS, Purdue	NAS9-9304
30Sep72	01Oct72	SE California (USGS)	66M	Geology	L. Rowan/K. Watson	USGS, Denver	NAS9-9304

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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TABLE 4. M7 MULTISPECTRAL SCANNER MISSIONS (Continued)

Sheet 3 of 4 Sheets

Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No.
30Sep72	01Oct72	Halloran Springs, Calif.		Geology	H. Rib	FHA, Washington, D.C.	FH11-7136
14Sep72	14Sep72	Michigan Oakworm	85M	Forestry	A. Andersen	MSU	NAS9-9304
13Sep72	13Sep72	Test Flight		Hydrology	P. Hasell	ERIM	
07Sep72	07Sep72	Lake Ontario	64M	Hydrology	F. Polcyn	ERIM	NAS9-9304
30Aug72	05Sep72	Genesee County Lakes Study		Hydrology	C. Wezernak	ERIM	GI-34809X
30Aug72	30Aug72	Genesee Co., Vienna Twp.		Land Use	E. Jebe	ERIM	GI-34809X
28Aug72	29Aug72	Lake Michigan/S. Michigan		Hydrology	C. Wezernak	ERIM	
29Aug72	29Aug72	Oakland County & Pt. Mouillee, Michigan		Land Use	L. Istvan/I. Sattinger	ERIM	NAS9-9304
13Aug72	25Aug72	Eaton County, Michigan	63M	Multi	W, Malila, R. Nalepka, A. Andersen	ERIM MSU	NAS9-9304
19Aug72	19Aug72	Tampa Bay, Florida	62M	Hydrology	C. Wezernak	ERIM	NAS9-9304
18Aug72	19Aug72	SE Florida	62M	Oceanog.	C. Wezernak	ERIM	NAS9-9304
16Aug72	16Aug72	New York Bight	62M	Oceanog.	C. Wezernak	ERIM	NAS9-9304
09Aug72	10Aug72	Wabash R. Basin, Indiana	61M	Multi	D. Landgrebe	LARS, Purdue	NAS9-9304
04Aug72	04Aug72	Test Flight		Agriculture	P. Hasell	ERIM	
20Jun72	31Jul72	Lake Ontario (EPA)		Hydrology	C. Wezernak	ERIM	R-80078
28Jul72	28Jul72	Woodworth, North Dakota	60M	Hydrol/Game Mgt.	H. Nelson	N.Prairie Wildlife Res.Center	NAS9-9304
22Jul72	24Jul72	N.Great Plains, S. Dakota	60M	Multi	V. Myers	S.Dakota State U., Brookings	NAS9-9304
28Jun72	30Jun72	Mill Creek, Oklahoma	59M	Geology	K. Watson	USGS, Denver	NAS9-9304
17Jun72	18Jun72	Lake Ontario (NASA)	58M	Hydrology	F. Polcyn	ERIM	NAS9-9304
05Jun72	05Jun72	Ann Arbor, Michigan	57M	Forestry	C. Olson	U. of M.	NAS9-9304
24May72	25May72	Black Hills, Forestry	56M	Forestry	R. Heller	U.S. Forest Service, Berkeley	NAS9-9304
21May72	21May72	Black Hills, Bu. of Mines		Geology	P. Jackson/T. Wagner	ERIM	HO-220064
19May72	19May72	Woodworth, North Dakota	56M	Hydrol/Game Mgt.	H. Nelson	N.Prairie Wildlife Res.Center	NAS9-9304
12May72	12May72	Wallops/Painter, Virginia		Agriculture	J. Bettle	NASA, Wallops Station,Virginia	NAS6-2058
12May72	12May72	Cambridge, Maryland		Multi	W. Rohde	U, S. Army	
11May72	11May72	Baltimore	55M	Urban	R. Pease/S. Outcalt	U.of California, U. of M.	NAS9-9304
05May72	05May72	SE Michigan	54M	Land Use	L. Istvan	ERIM	NAS9-9304
04May72	04May72	Local Test		Multi	P. Hasell	ERIM	

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 4 of 4 Sheets

Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No.
11Nov71	12Nov71	Houston Area Test Site(HATS)	51M	Multi	R. Erb	NASA/JSC	NAS9-9304
03Nov71	05Nov71	Atlanta, Georgia	53M	Forestry	R.Aldrich/R.Heller	U.S.Forest Service, Berkeley	NAS9-9304
28Oct71	28Oct71	Local Test		Multi	P. Hasell	ERIM	
24Sep71	06Oct71	Corn Blight	46M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
21Sep71	21Sep71	Ingham County & MSU Ag.Farm	46M	Agriculture	W. Malila/R. Nalepka, A. Ellingboe	ERIM M.S.U.	NAS9-9304
17Sep71	18Sep71	Genesee County, Michigan		Land Use	F. Polcyn/A. Sellman	ERIM	GI-30027
15Sep71	15Sep71	Test Flight		Land Use	P. Hasell	ERIM	
14Sep71	15Sep71	Corn Blight	45M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
26Aug71	29Aug71	Corn Blight	44M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
17Aug71	17Aug71	Ingham County & MSU Ag.Farm	43M	Agriculture	W. Malila/R. Nalepka A. Ellingboe	ERIM M.S.U.	NAS9-9304
11Aug71	17Aug71	Corn Blight	43M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
06Aug71	06Aug71	Ingham County & MSU Ag.Farm	42M	Agriculture	W. Malila/R. Nalepka A. Ellingboe	ERIM M.S.U.	NAS9-9304
27Jul71	05Aug71	Corn Blight	42M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
12Jul71	21Jul71	Corn Blight	41M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
07Jul71	07Jul71	Michigan Ag. Farm	40M	Agriculture	W. Malila/R. Nalepka A. Ellingboe	ERIM M.S.U.	NAS9-9304
28Jun71	07Jul71	Corn Blight	40M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 5. M5 MULTISPECTRAL SCANNER MISSIONS

Sheet 1 of 6 Sheets

Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No. Agency
17Sep71	17Sep71	Genesee County, MI		Land Use	F. Polcyn/A. Sellman	ERIM	GI-30027
11Aug71	13Aug71	Corn Blight	43M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
06Aug71	06Aug71	Ingham County, MI	42M	Agriculture	W. Malila/R. Nalepka	ERIM	NAS9-9304
		Michigan State Ag. Farm			A. Ellingboe	MSU, Lansing	
27Jul71	05Aug71	Corn Blight	42M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
12Jul71	16Jul71	Corn Blight	41M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
07Jul71	07Jul71	Michigan State Ag. Farm	40M	Agriculture	W. Malila/R. Nalepka	ERIM	NAS9-9304
					A. Ellingboe	MSU, Lansing	
28Jun71	07Jul71	Corn Blight	40M	Agriculture	D. Landgrebe	LARS, Purdue	NAS9-9304
28May71	28May71	Lake Michigan		Hydrology	F. Polcyn	ERIM	NAS9-9304
22May71	22May71	Michigan State Ag. Farm		Agriculture	W. Malila/R. Nalepka	ERIM	NAS9-9304
17May71	22May71	Corn Blight	38M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
10May71	11May71	Lake Ontario		Multi	T. Wagner	ERIM	DACW35-70-C-0056
07May71	07May71	Lake Michigan		Hydrology	F. Polcyn	ERIM	Indiana-Michigan Power Co.
05May71	07May71	Sumpter Township, MI		Multi	F. Polcyn	ERIM	PO #49883
30Apr71	30Apr71	Lake Michigan		Hydrology	F. Polcyn	ERIM	Northern Indiana Pub. Service Co.
22Apr71	23Apr71	Lake Michigan		Hydrology	F. Polcyn	ERIM	Consumer's Power Co.
21Apr71	21Apr71	Local Test		Test	P. Hasell	ERIM	NAS9-9304
11Mar71	11Mar71	Tennessee Valley	34M	Multi	R. MacDonald	LARS, Purdue	NAS9-9304
08Mar71	09Mar71	Houston, TX	35M	Multi	M. Holter	ERIM	NAS9-9304
04Mar71	04Mar71	Port Lavaca Bay, TX	35M	Multi	M. Holter	ERIM	NAS9-9304
27Feb71	04Mar71	Weslaco, TX	32M	Agriculture	C. Wiegand	USDA, Weslaco	NAS9-9304
14Dec70	15Dec70	Staunton, VA		Multi	D. Noble	VA Hwy. Administration	Hwy.Res.Comm.
29Oct70	30Oct70	Pisgah Crater, CAL	31M	Geology	R. Vincent	ERIM	NAS9-9304
28Oct70	28Oct70	Oil Spill, CAL		Oceanog.	R. Horvath	ERIM	DOT-CG-92580-A
16Oct70	16Oct70	Forest Sites, MI	24M	Forestry	C. Olson	UM, Ann Arbor	NAS9-9304

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No. Agency
29Sep70	01Oct70	Ann Arbor Test Site, MI	24M	Forestry	C. Olson	UM, Ann Arbor	NAS9-9304
23Sep70	23Sep70	Tennessee Valley	22M	Multi	R. MacDonald	LARS, Purdue	NAS9-9304
18Sep70	21Sep70	Florida Sink Hole	22M	Multi	A. Coker	USGS, Tampa	NAS9-9304
11Sep70	11Sep70	Corn Blight	28M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
09Sep70	09Sep70	Power Plants		Hydrology	F. Polcyn	ERIM	Consumer's Power Co.
05Sep70	05Sep70	Corn Blight	28M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
27Aug70	27Aug70	Catheart Mountain, ME	21M	Multi	F. Canney	USGS, Denver	NAS9-9304
24Aug70	24Aug70	Corn Blight	28M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
21Aug70	21Aug70	Lenawee & Washtenaw Cos,MI	20M	Agriculture	R. Nalepka	ERIM	NAS9-9304
11Aug70	13Aug70	Tippecanoe Co., IND	20M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
05Aug70	06Aug70	Ann Arbor, MI	20M	Forestry	C. Olson	UM, Ann Arbor	NAS9-9304
31Jul70	31Jul70	Jamestown, ND	19M	Multi	J. Johnston	USGS, Washington, D.C.	NAS9-9304
					F. Polcyn	ERIM	
28Jul70	29Jul70	Manitou, COLO	19M	Multi	R. Driscoll	USDA, Colorado	NAS9-9304
21Jul70	22Jul70	Local		Multi	M. Bair	ERIM	F33615-70-C-3692
17Jul70	17Jul70	Traverse Bay, MI		Hydrology	F. Polcyn	ERIM	NSF GH-98
16Jul70	17Jul70	Pellston, MI		Multi	E. Work/T. Wagner	ERIM	UM,IST(Wilson)
13Jul70	13Jul70	Detroit River,Willow Run, and Dundee, MI		Land Use	M. Bair	ERIM	F33615-70-C-1698
06Jul70	07Jul70	Ann Arbor, MI	18M	Forestry	C. Olson	UM, Ann Arbor	NAS9-9304
30Jun70	01Jul70	Purdue, IND	17M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
23Jun70	26Jun70	Mill Creek, OK	16M	Geology	L. Rowan	USGS, Arizona	NAS9-9304
20Jun70	20Jun70	Lenawee & Washtenaw Cos,MI	15M	Agriculture	R. Nalepka	ERIM	NAS9-9304
08Jun70	08Jun70	Ann Arbor, MI	15M	Forestry	C. Olson	UM, Ann Arbor	NAS9-9304
23May70	23May70	Minnesota Pot Holes	14M	Multi	J. Johnston	USGS, Washington, D. C.	NAS9-9304
21May70	23May70	North Dakota	14M	Multi	J. Johnston	USGS, Washington, D. C.	NAS9-9304
					T. Klett	NPWRC, Jamestown	
07May70	07May70	Lake Michigan		Hydrology	F. Polcyn	ERIM	IND/MI Electric Co.
06May70	06May70	Purdue, IND	12M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 5. M5 MULTISPECTRAL SCANNER MISSIONS
(Continued)

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Flight Date		Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No. Agency
First	Last						
07Apr70	08Apr70	Staunton, VA		Multi	D. Noble	VA Hwy. Administration	Hwy.Res.Comm.
26Mar70	26Mar70	Kansas		Multi	H. Rib	FHA, Washington, D. C.	FH-11-7136
10Mar70	10Mar70	Biscayne Bay, FLA		Oceanog.	M. Kolipinski	USGS, Miami	NAS9-9304
					F. Polcyn	ERIM	
17Dec69	17Dec69	Purdue, IND	10M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
					C. Johannsen	LARS, Purdue	
26Nov69	26Nov69	Ann Arbor Forestry, MI	8M	Multi	C. Olson	UM, Ann Arbor	NAS9-9304
					F. Polcyn	ERIM	
20Nov69	20Nov69	Detroit River, MI		Multi	F. Polcyn	ERIM	NSF GH-50
05Nov69	06Nov69	Purdue, IND		Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
25Oct69	27Oct69	Los Angeles Forestry, CAL		Forestry	S. Wert	US Forest Service, Berkeley	USDA 21-133
24Oct69	24Oct69	Bucks Lake, WA		Forestry	Lent/Colwell	U of C, Berkeley	14-06-D-6840
22Oct69	23Oct69	Moses Lake, WA		Geology	C. Maierhofer	Bureau of Recl., Denver	14-06-D-6840
26Sep69	26Sep69	Wind River, WA		Forestry	P. Weber	US Forest Service, Berkeley	NAS9-9304
25Sep69	25Sep69	Moses Lake, WA		Multi	C. Maierhofer	Bureau of Recl., Denver	NAS9-9304
14Sep69	24Sep69	Oregon Coast	8M	Oceanog.	W. Pearcy	OSU, Corvallis	NAS9-9304
03Sep69	03Sep69	Washtenaw Co., Willow Run	8M	Multi	R. Maxwell	ERIM	NAS9-9304
13Aug69	13Aug69	Ann Arbor Forestry, MI	7M	Forestry	C. Olson	UM, Ann Arbor	NAS9-9304
13Aug69	13Aug69	Detroit River, MI		Multi	S. Stewart	ERIM	NSF GH-50
11Aug69	11Aug69	Lake Michigan	7M	Hydrology	F. Polcyn	ERIM	NAS9-9304
05Aug69	06Aug69	Purdue, IND	7M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
04Aug69	04Aug69	Ann Arbor, MI	7M	Forestry	C. Olson	UM, Ann Arbor	NAS9-9304
23Jul69	23Jul69	Missouri River, MO	6M	Multi	J. Snell	ERIM	NAS9-9304
21Jul69	22Jul69	Black Hills, SD	6M	Forestry	P. Weber	US Forest Service, Berkeley	NAS9-9304
16Jul69	16Jul69	Bucks Lake, CAL	6M	Forestry	J. Lent	U of C, Berkeley	NAS9-9304
14Jul69	15Jul69	Wind River, WA	6M	Forestry	P. Weber	US Forest Service, Berkeley	NAS9-9304
03Jul69	12Jul69	Corvallis, ORE	6M	Oceanog.	W. Pearcy	OSU, Corvallis	NAS9-9304
25Jun69	26Jun69	Purdue, IND	5M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
27May69	27May69	Lake Michigan		Hydrology	F. Polcyn	ERIM	N62306-67-C-0243
13May69	27May69	Tippecanoe County, IND	4M	Agriculture	R. MacDonald	LARS, Purdue	NAS9-9304
15May69	15May69	Harrisburg, PA		Multi	H. Rib	FHA, Washington, D. C.	FH-11-7136

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Flight Date		Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No. Agency
First	Last						
12May69	12May69	Local Test		Multi	P. Hasell	ERIM	ERIM
08Mar69	12Mar69	San Diego, CAL	3M	Multi	D. Lowe	ERIM	NAS9-9304
06Mar69	07Mar69	Santa Barbara, CAL		Oceanog.	F. Polcyn/F. Thomson	ERIM	14-12-517
					J. Denoyer	U.S. Dept. of Interior	
26Feb69	26Feb69	Local Test		Multi	P. Hasell	ERIM	ERIM
21Oct68	21Oct68	Local		Multi	C. Olson	UM, Ann Arbor	NASW-1604
15Oct68	15Oct68	Knoxville, TENN	2M	Hydrology	R. Witmer	E Tenn State Univ,Johnson Cty	NAS9-8381
26Sep68	26Sep68	Enroute Test		Hydrology	P. Hasell	ERIM	ERIM
26Sep68	26Sep68	Tippecanoe County, IND	1M	Agriculture			NASA/JSC
23Sep68	23Sep68	Mono Lake, CAL		Geology	R. Fowler	North American Rockwell	NAR
20Sep68	20Sep68	Bucks Lake, CAL		Multi	R. Fowler	North American Rockwell	NAR
17Sep68	17Sep68	Fort Collins, COLO		Multi	R. Fowler	North American Rockwell	NAR
09Sep68	09Sep68	Local Test		Multi	P. Hasell	ERIM	ERIM
22Aug68	22Aug68	Local Test		Multi	P. Hasell	ERIM	ERIM
22Aug68	22Aug68	Detroit River, MI		Multi	P. Hasell	ERIM	12-14-100-
						USDA, Agri. Res. Service	9503
30Jul68	30Jul68	Tippecanoe County, IND		Agriculture	R. Hoffer	LARS, Purdue	NAS9-8381
25Jul68	25Jul68	Local Test		Multi	P. Hasell	ERIM	ERIM
31May68	31May68	Woodworth, ND		Multi	H. Nelson	NPWRC, Jamestown	USGS-14-08-001-11201
29May68	30May68	Rapid City, SD		Forestry	R. Heller/P. Weber	US Forest Service, Berkeley	PO #62915
22May68	22May68	Local Test		Multi	P. Hasell	ERIM	ERIM
08Nov67	08Nov67	Local Test		Multi	P. Hasell	ERIM	ERIM
30Sep67	16Oct67	Barrow, AK		Multi	R. Horvath	ERIM	USGS-14-08-001-11201
19Sep67	22Sep67	Yellowstone, WYO		Multi	H. James	USGS, Washington, D. C.	USGS-14-08-001-11201
07Sep67	07Sep67	Miami, FLA		Oceanog.	A. Higer	USGS, Miami	USGS-14-08-
					W. Hemphill	USGS, Arlington	001-11201
05Sep67	06Sep67	Tampa, FLA		Multi	W. Hemphill	USGS, Arlington	USGS-14-08-001-11201

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 5. M5 MULTISPECTRAL SCANNER MISSIONS
(Continued)

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Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No. Agency
04Sep67	04Sep67	Asheville, NC		Multi	W. Hemphill	USGS, Arlington	USGS-14-08-
							001-11201
03Sep67	04Sep67	TVA		Multi	R. Elder	TVA, Norris, Tennessee	TV29629A
					W. Hemphill	USGS, Arlington	
23Aug67	23Aug67	Local Test		Multi	P. Hasell	ERIM	ERIM
06Jul67	06Jul67	Toledo OH/Detroit,Port			D. Lowe	ERIM	ERIM
		Huron, MI					
27Jun67	27Jun67	Local Test		Multi	P. Hasell	ERIM	ERIM
28Apr67	28Apr67	Indianapolis, IND		Multi	R. Miles	LARS, Purdue	PO #33486
15Mar67	15Mar67	Willow Run, MI		Multi	W. Malila	ERIM	DA 28 043
							AMC 00013
14Mar67	14Mar67	Willow Run, MI		Multi	W. Malila/N. Spansail	ERIM	DA 28 043
							AMC 00013
02Mar67	12Mar67	Willow Run, MI		Multi	W. Malila	ERIM	DA 28 043
							AMC 00013
15Dec66	15Dec66	Local Test		Multi	P. Hasell	ERIM	ERIM
22Nov66	22Nov66	Local Test		Multi	P. Hasell	ERIM	ERIM
18Nov66	18Nov66	Local Test		Multi	P. Hasell	ERIM	ERIM
14Nov66	14Nov66	Local Test		Multi	P. Hasell	ERIM	ERIM
15Sep66	15Sep66	Purdue, IND		Agriculture	R. Hoffer	LARS, Purdue	NASA/NSG 175
01Sep66	01Sep66	Local Test		Forestry	P. Hasell	ERIM	ERIM
30Aug66	30Aug66	Local Test		Multi	P. Hasell	ERIM	ERIM
25Aug66	25Aug66	Local Test		Multi	P. Hasell	ERIM	ERIM
26Jul66	29Jul66	Purdue, IND		Agriculture	R. Hoffer	LARS, Purdue	NASA/NSG 175
21Jul66	21Jul66	Local Test		Multi	P. Hasell	ERIM	ERIM
28Jun66	30Jun66	Purdue, IND		Agriculture	R. Hoffer	LARS, Purdue	NASA/NSG 175
24Jun66	24Jun66	Local Test		Multi	P. Hasell	ERIM	ERIM
30May66	02Jun66	Weslaco, TX		Agriculture	R. Leamer/V. Myers	USDA, Weslaco	USDA PO S
							15182
17May66	26May66	California		Multi	R. Colwell	U of C, Berkeley	
					W. Hemphill	USGS, Arlington	POG909 140
05May66	06May66	Purdue, IND		Agriculture	P. Hasell	ERIM	NASA/NSG 175

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Flight Date First	Flight Date Last	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No. Agency
04May66	04May66	Local Test		Agriculture	P. Hasell	ERIM	ERIM
29Apr66	29Apr66	Toledo OH, Lake Erie		Hydrology	P. Hasell	ERIM	NASA/NSG 175
28Apr66	28Apr66	Ann Arbor, MI		Multi	P. Hasell	ERIM	NASA/NSG 175
11Mar66	21Mar66	Ann Arbor, MI		Multi	P. Hasell	ERIM	DA 28049-AMC-
							00013(E)
02Feb66	02Feb66	Ann Arbor, MI		Multi	P. Hasell	ERIM	DA 28049-AMC-
							00013(E)
06Jan66	06Jan66	Ann Arbor, MI		Multi	P. Hasell	ERIM	DA 28049-AMC-
							00013(E)

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 6. M1A1 THERMAL SCANNER MISSIONS

First Flight Date	Last Flight Date	Mission Title	Major Discipline	Principal Investigator	PI Organization	Contract No.
19 Jan 71	28 Jan 71	Puerto Rico	Hydro	Dr. T.P. Rooney	AFCRL	F19628-68-C-0076
01 Dec 70	05 Dec 70	So. Calif.	Geol	Dr. T.P. Rooney	AFCRL	F19628-68-C-0076
17 Nov 70	18 Nov 70	US East Coast	Hydro	Dr. T.P. Rooney	AFCRL	F19628-68-C-0076
14 Jul 70	22 Jul 70	US West Coast	Geol	Dr. T.P. Rooney	AFCRL	F19628-68-C-0076
30 Apr 69	02 May 69	US East Coast	Hydro	Dr. R.S. Williams	AFCRL	F19628-68-C-0076
09 Apr 69	09 Apr 69	Yellowstone	Geol	Dr. R.S. Williams	AFCRL	F19628-68-C-0076
10 Jan 69	11 Jan 69	Nevada	Geol	Dr. R.S. Williams	AFCRL	F19628-68-C-0076
21 Nov 68	18 Dec 68	Puerto Rico	Geol	Dr. R.S. Williams	AFCRL	F19628-68-C-0076
19 Oct 68	01 Nov 68	Iceland	Geol	Dr. R.S. Williams	AFCRL	F19628-68-C-0076

TABLE 7. SLAR X-L BAND RADAR MISSIONS

First Flight Date	Last Flight Date	Mission Title	NASA No.	Major Discipline	Principal Investigator	PI Organization	Contract No.
18 Apr 74	18 Apr 74	Oconee Co., Ga.	91 m	Agri	T. Davis	NASA KSC	NAS9-13829
03 Apr 74	05 Apr 74	Phoenix, Ariz.	90 m	Agri	A. Potter/T. Schmugee	NASA/JSC/GSFC	NAS9-13829
13 Mar 74	13 Mar 74	White Fish Bay, Mich.	73 m	Hydrology	R. Gedneg	NASA/Lewis	NAS3-18239
07 Oct 73	12 Oct 73	Fla. Waterways	NASA	Hydrology	E. Hecker	NASA/KSC	NAS10-8333
05 Oct 73	05 Oct 73	Mich., Ohio, Kentucky	—	Geology	L. Porcello	ERIM	NAS10-8333
13 Sep 73	03 Oct 73	Huntington Co., Ind.	88 m	Agri	A. Potter	NASA/JSC	NAS10-8333
28 Mar 73	05 Apr 73	Southern Michigan	76 m	Hydrology	L. Porcello	ERIM	NAS9-9304
13 Aug 72	13 Aug 73	Georgia Co's	NASA	Agri	A. Potter	NASA/JSC	F33615-71-C-1895
17 May 72	19 May 72	Georgia & Florida Co's	NASA	Agri	A. Potter	NASA/JSC	F33615-71-C-1895
17 Apr 72	25 Apr 72	Harris, Texas	NASA 51 m	Agri	R. Bryan Erb.	NASA/JSC	NAS9-11036
01 Oct 71	08 Oct 71	So. Calif.	48 m & 49 m	Geology	R. Moore	U. of Kansas	NAS9-11036
24 Aug 71	31 Aug 71	So. Calif.	48 m & 49 m	Geology	R. Moore	U. of Kansas	NAS9-11036
22 Jul 71	21 Aug 71	Garden City, Kansas	48 m & 49 m	Geology	R. Moore	U. of Kansas	NAS9-11036
23 Jun 71	23 Jun 71	L. Ontario, N.Y.	—	Geology	C. Freeze	Corp. of Eng. (Det. Office)	DACD35-70-C-0056
23 Sep 69	01 Oct 69	Kansas, Okla.	NASA JSC	Agri	R. Moore	U. of Kansas	NAS9-10211
29 May 68	05 Apr 68	Mich. & Ontario	—	Hydrology	Bill Marshall	Corp. of Eng. (Det. Office)	Sub Acct. of Parent 6400 "Project Michigan" whose Contract No. is DA-28-043 AMC-00013(E)

3.2.2 FLIGHT LISTINGS

The specific flights for each imagery source are listed by (1) the flight date and time index, (2) the site description consisting of the coded site location and key objects in the scene, (3) the nominal spatial resolution within the scene, (4) the coded identification and number of imagery bands,(5) the coded identification and number of boresight camera bands and (6) the total length of the flight line. Descriptions of the site location and imagery identification codes are presented in Appendix B. A flight is identified in this report as a planned single airborne operation including one takeoff and landing. However, occasionally two or more planned flights were accomplished in one airborne operation. When this happened, the listing of flights was usually made as planned, not as accomplished.

The site location code identifies the one degree quadrant of longitude and latitude that contains the site flight lines. Sometimes a site is partially in several quadrants. When this happens all quadrants containing imagery are listed.

The flights made with the M7 multispectral scanner system are listed in Table 8. Flights made from June 1971 through December 1974 are included.

The flights made with the M5 multispectral scanner system are listed in Table 9. Flights made during the active time period of this system, January 1966 through December 1971, are included.

The flights listed in Table 10 for the M1A1 system are those made during the active life of this system (1968-1971), when the imagery was tape-recorded.

The flights listed in Table 11 for the SLAR system are those made for earth resources investigations over the period January 1968 through December 1974.

TABLE 8. M7 MULTISPECTRAL SCANNER FLIGHTS

Sheet 1 of 7 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
03Oct74	0900	GJCK-250	Wabash River Basin	3,7	1	9	1	-	1	1	1	1	34
02Oct74	1000	GJGN-190	Local Test	1,2,10	1	9	1	-	1	1	-	-	58
01Aug74	0500	GJEJ	Indiana Power Plants	9	-	-	-	-	2	-	-	-	34
31Jul74	1100	GJEJ	Indiana Power Plants	6,10	1	9	-	-	2	1	-	1	34
31Jul74	0400	GJEJ	Indiana Power Plants	9	-	-	-	-	2	-	-	-	34
21May74	1030	GJKK	Coal Mines	2	1	8	2	-	1	1	1	1	125
20May74	0930	GJKK	Coal Mines	2,6	1	8	2	-	1	1	1	1	163
08May74	0930	GKFA,EA,EB	Michigan U. P. Shoreline	5	1	8	2	-	1	-	1	1	115
07May74	1400	GKGB,FB,EB,DB,CB	Michigan U. P. Shoreline	5,8	1	8	2	-	1	-	1	1	317
07May74	0930	GJHP,HQ,GP,GQ,GKGA	Lake Huron Shoreline (Mich.)	5	1	8	2	-	1	-	1	1	377
26Apr74	1000	FKQB,GKAB,BC,BB,CB,CA,DA,EA	Michigan U. P. Shoreline	5	1	8	2	-	1	-	1	1	442
24Apr74	1030	GKEA,GJEQ,DQ,DP,DN,DM	Lake Michigan Shoreline	5	1	8	2	-	1	-	1	1	375
17Apr74	0930	GJGD	A.E.S. - U. of Georgia	2,3	1	7	3	-	1	1	-	-	29
10Apr74	1000	GJGM,GN,HN,HP,HQ	SE Michigan Shoreline	3,5	1	8	2	-	1	-	1	1	234
08Apr74	1000	GJFP	Oil Refinery	1,2	1	7	-	-	2	1	-	-	22
03Apr74	0900	GJGN	Test Flight	1,8	1	7	-	-	2	1	-	-	38
20Mar74	1000	GHKN	Fort Pierce Inlet	2	-	8	3	-	1	1	-	-	22
20Mar74	1000	GHKN	Citrus Groves	5	-	8	3	-	1	2	1	-	16
19Mar74	0930	GHJQ	Soils	3,6	1	9	-	-	2	-	-	-	32
19Mar74	0800	GHJQ	Oklawaha River, Florida	3	1	9	-	-	2	2	1	1	22
14Mar74	1700	GJGN	Ann Arbor, Michigan	2,3,5,10	1	9	1	-	1	3	-	-	40
30Jan74	1100	GJEM,DM,CM-250	Wabash River Basin	8	-	9	2	-	1	1	1	1	120
20Nov73	1100	GJGN-190	Belleville, Michigan	2	1	8	2	-	1	3	-	-	23
18Sep73	1000	GJDN-167	Lake Michigan	1,5,6,10	1	7	2	-	1	1	-	1	39
13Sep73	1200	GJDN	Michigan Power Plants	2,5	1	7	3	-	1	2	1	-	55
11Sep73	0545	GJLP-239	Guelph, Ontario	1,3	-	-	-	-	1	-	-	-	68
10Sep73	1200	GJLP,MP-239	Lake Ontario	5,6,8	-	6	5	-	1	1	1	1	232
07Sep73	1345	GJEQ-279	Oak Worm Infestation	4,6	1	7	2	-	1	1	1	1	39
07Sep73	1600	GJDQ-167	Lake Michigan	1,5,10	1	7	2	-	1	1	1	1	39
06Sep73	1000	GJGN,GM	Agriculture, Willow Run	1,2,4,5,10	-	6	5	-	1	1	1	1	77
28Aug73	1330	GJHN	Land Use, Highway Site	8	-	7	4	-	1	1	1	1	167
22Aug73	0830	GJGN	Genesee County Lakes	1,5	-	7	4	-	1	1	1	1	82

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 2 of 7 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
21Aug73	0900	GJAJ,AK,EL,DL,EK-044	Agriculture	14	-	7	4	-	1	1	-	2	224
20Aug73	1200	GJBL,AM-044	Agriculture	14	-	7	4	-	1	1	-	2	113
12Aug73	0830	FKEC,FB,FC-216	Waterfowl Habitat	4,5	-	6	5	-	1	1	1	1	309
10Aug73	1615	GJCQ	Wisconsin Power Plants	2,4	1	8	2	-	1	3	-	1	48
05Aug73	0830	GJFN-279	Agriculture	1,2,5,10	-	8	3	-	1	1	1	1	277
04Aug73	0930	GJFM,FN,GM,GN-279	Agriculture	12	-	6	5	-	1	1	1	1	460
02Aug73	1500	GJGN	Willow Run	1	-	6	5	-	1	-	-	-	19
07Jul73	0815	GJEK,EL-044	Agriculture	14	-	7	4	-	1	1	-	2	113
06Jul73	0900	GJEL,DL,EK-044	Agriculture	14	-	7	4	-	1	1	-	2	167
05Jul73	0900	GJAJ,AK,BL,AM-044	Agriculture	14	-	7	4	-	1	1	-	2	167
03Jul73	1030	GJGN	Genesee County Lakes	1	1	7	3	-	1	1	1	1	45
25Jun73	1015	GJGN	Agriculture, Willow Run	2,3	-	7	4	-	1	1	1	1	40
22Jun73	0930	GJGN	Genesee County Lakes	1	1	7	3	-	1	1	1	1	39
14Jun73	0500	GJGP	Land Use	4	1	7	3	-	1	-	-	-	90
11Jun73	1000	GJDM,DN,DP-167	SW Michigan Shoreline	5	1	7	3	-	1	-	-	-	71
10Jun73	0830	GJDK,DJ,CK-371	Wabash River Basin	5	-	8	3	-	1	1	1	1	37
08Jun73	0930	GJGN,FN-190	Agriculture	6,13	1	7	4	-	1	1	1	1	100
07Jun73	0930	GJGP	Land Use	1	1	7	3	-	1	1	1	1	34
31May73	0930	GJHN	Land Use - Highway Site	8	1	7	3	-	1	1	1	1	155
31May73	0930	GJGP	Land Use	4	1	7	3	-	1	1	1	1	77
31May73	0930	GJGN	Genesee County Lakes	5	1	7	3	-	1	1	1	1	66
24May73	1000	GJHN,GN	Land Use - Highway Site, Ford Lake	1,10	1	7	2	-	1	3	-	-	71
12May73	0730	FKEC,FB,FC-216	Waterfowl Habitat	5	1	7	3	-	1	1	1	1	232
04May73	0930	GJDK,CJ,CK,DL-250	Wabash River Basin	2,5,10	-	8	3	-	1	2	1	1	240
20Apr73	0600	FJJH,HH	Agriculture	6	1	6	4	-	1	1	1	1	99
19Apr73	1130	FJJH,HH	Agriculture	4	1	6	4	-	1	1	1	1	389
13Apr73	1300	GJGN,GP,HN,FP	SE Michigan Shoreline	1,2,3,5	1	7	3	-	1	1	1	1	89
11Apr73	1100	GJHN	Land Use - Highway Site	5	1	7	3	-	1	1	1	1	35
11Apr73	1100	GJEQ	Forest Site	1,2,4,5	1	7	3	-	1	2	1	1	43
11Apr73	0830	GJGM	Lake Erie Flooding	10	1	8	2	-	1	2	-	1	135
07Apr73	1300	HJAL,BL-188	Water Pollution, NY Bay	10	1	8	2	-	1	1	2	-	308

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 8. M7 MULTISPECTRAL SCANNER FLIGHTS
(Continued)

Sheet 3 of 7 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
07Apr73	0800	HJAL,BL-188	Water Pollution, NY Bay	10	1	8	2	-	1	1	2	-	308
06Apr73	1300	HJBL-188	Water Pollution, NY Bay	10	1	8	2	-	1	1	2	-	77
25Mar73	1000	GJLP,MP,NP-239	S Shore Lake Ontario	5,7,9	1	8	2	-	1	1	2	1	77
24Mar73	0930	GJKP,LP,MP,NP,PP-239	Guelph & S Shore L. Ontario	4,10	1	8	2	-	1	1	2	1	238
23Mar73	0930	GJGM,GN	Lake Erie Flooding	2,10	-	7	4	-	1	3	-	-	35
20Mar73	1030	GJGN	Forest Sites	3	-	7	4	-	1	2	1	1	19
20Mar73	1030	GJGP	Saginaw Bay Flooding	5,10	-	7	5	-	1	1	1	1	114
25Jan73	0900	GJDM,DN,DP	SW Michigan Shoreline	5	1	7	3	-	1	1	1	1	63
12Jan73	1400	GJGN,GP,HN,FP	SE Michigan & Saginaw Bay	1,5	1	7	3	-	1	1	1	1	35
			Shoreline										
10Jan73	0900	GJGN,GP,HN	SE Michigan & Saginaw Bay	1,3,5	1	7	3	-	1	1	1	1	66
			Shoreline										
02Jan73	1000	GJDK-250	Wabash River Basin	2,5	-	8	3	-	1	1	1	1	30
17Nov72	0900	GHHN-233	Tampa Bay	11	1	8	2	-	1	2	1	-	106
16Nov72	0900	GHKL,KM	SE Florida Shoreline	2,11	1	8	2	-	1	2	1	-	181
19Oct72	0930	GJGN,FN-190	Lansing & Ann Arbor,Mich.	1,5	1	6	3	-	2	1	1	1	71
17Oct72	1000	GJCK,CL,DK,DL-250	Wabash River Basin	5,10	-	8	3	-	1	2	1	1	97
01Oct72	0700	EJEF,DE,DF-130	SE California	7	1	5	3	-	3	2	-	-	163
01Oct72	0500	EJDF-002	Halloran Springs	3,6	1	-	-	-	3	-	-	-	56
30Sep72	1200	EJEF,DE,DF-130	SE California	7	1	5	3	-	3	2	1	1	163
30Sep72	1000	EJDF-002	Halloran Springs	3,6	1	6	3	-	2	2	-	1	56
14Sep72	1300	GJFN	Agriculture	2,5	-	7	4	-	1	2	1	1	19
14Sep72	1300	GJEQ-279	Oakworm Infestation	3,4,6	-	7	4	-	1	2	1	1	58
13Sep72	1300	GJGN	Ford Lake & Belleville Lake	2	-	7	4	-	1	-	-	-	18
07Sep72	0830	GJKP,MP-239	Guelph, Ontario	4,5	1	8	2	-	1	1	1	1	142
05Sep72	0900	GJGN	Genesee County Lakes	1	1	7	3	-	1	1	-	1	34
30Aug72	1030	GJGN	Land Use	5	1	7	3	-	1	2	-	1	63
30Aug72	1030	GJGP	Genesee County Lakes	4	1	7	3	-	1	2	-	1	77
29Aug72	1400	GJGM,GN,HN,HP,HQ,GP,GQ	SE Michigan & Saginaw Bay	1,2,5	1	7	3	-	1	1	1	1	94
			Shoreline										
29Aug72	0830	GJGM,GN-231	Pt. Mouillee Wetlands	2,4	-	7	4	-	1	1	1	1	111
28Aug72	0830	GJDM,DN,DP	SW Michigan Shoreline	5	1	7	3	-	1	1	1	1	69

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 4 of 7 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
25Aug72	1000	GJFN,GN-279	Agriculture	1,2,4,5,6,10	-	7	4	-	1	1	1	1	332
19Aug72	0900	GHHN-233	Tampa Bay	10	1	8	2	-	1	1	1	1	171
19Aug72	0900	GHKL,KM	SE Florida Shoreline	10	1	8	2	-	1	1	1	1	39
18Aug72	0900	GHKL,KM	SE Florida Shoreline	2,10	1	8	2	-	1	1	1	1	153
16Aug72	0900	HJBL-188	Water Pollution, NY Bight	10	1	8	2	-	1	1	1	1	76
13Aug72	0930	GJFN-279	Agriculture	1,2,4,5	-	7	4	-	1	1	1	1	56
10Aug72	1030	GJEK,EL,FK,FL,GK,GL-250	Wabash River Basin	2,5,10	-	8	3	-	1	2	1	1	147
09Aug72	0830	GJEK,EL,FK,FL,GK,GL-250	Wabash River Basin	2,5,10	-	8	3	-	1	2	1	1	173
04Aug72	0930	GJFN-279	Agriculture	1,2,3,8	-	6	4	-	1	2	-	1	65
31Jul72	1400	GJLP,MP,NP-239	S Shore Lake Ontario	2	1	8	2	-	1	1	4	-	271
28Jul72	1700	FKFC,GC-216	Waterfowl Habitat	2,5	1	7	4	0	1	1	2	1	194
24Jul72	1015	FJDP,DQ,CQ,CA-269	Soils, Landforms	10	-	6	5	-	1	4	-	1	106
23Jul72	1015	FJHQ,JQ,HA,GA-269	Soils, Landforms	10	-	6	5	-	1	4	-	1	60
22Jul72	1015	FJJN,JP-269	Soils, Landforms	10	-	6	5	-	1	4	-	1	15
30Jun72	0530	FJJE,FE,GE-178	Arbuckle & Wichita Mts.	1,3,7	1	6	4	-	6	2	-	-	194
28Jun72	1200	FJJE,FE,GE-178	Arbuckle & Wichita Mts.	1,3,7	1	6	4	-	4	3	1	-	108
20Jun72	0845	GJLP,MP,NP-239	S Shore Lake Ontario	1	1	8	2	-	1	2	2	-	248
18Jun72	0400	GJLP-239	W & S Shore Lake Ontario	2,4,5	-	-	2	-	2	-	-	-	97
17Jun72	1200	GJLP-239	W & S Shore Lake Ontario	1,3,5	-	7	4	-	1	2	1	-	213
05Jun72	1000	GJGN,FN-190	Forest Site	2,3	1	6	4	-	1	2	1	1	100
25May72	1130	FJBQ-149	Map Diseased Trees	2,8	-	6	5	-	1	2	1	-	39
25May72	0745	FJBQ-149	Map Diseased Trees	2,8	-	6	5	-	1	2	1	-	23
24May72	0830	FJBQ-149	Map Diseased Trees	8	-	6	5	-	1	2	1	-	3
21May72	1100	FJBQ	Black Hills, Geology	5	1	5	4	-	2	2	1	1	116
19May72	0730	FKFC,GC-216	Waterfowl Habitat	2,5	1	7	4	-	1	1	1	2	216
12May72	2140	GJQH	Virginia A.E.F.	1,3	-	-	-	-	2	-	-	-	19
12May72	1100	GJQH	Virginia A.E.F.	1,3	-	8	3	-	1	1	1	2	19
12May72	0900	GJPJ	Agriculture	3	-	8	3	-	1	2	-	1	31
11May72	1345	GJPK-017	Downtown Baltimore	3,5	-	8	3	-	1	4	-	-	77
11May72	1015	GJPK-017	Downtown Baltimore	3,5	-	8	3	-	1	4	-	-	77
11May72	0515	GJPK-017	Downtown Baltimore	3,5	-	8	3	-	1	1	-	-	77
05May72	1000	GJGM,GN	Pt. Mouillee Wetlands	1,2,4,8	-	8	3	-	1	3	-	1	134

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 8. M7 MULTISPECTRAL SCANNER FLIGHTS (Continued)

Sheet 5 of 7 Sheets

Flight Index: Date	Flight Index: Time	Site Description: Location	Site Description: Objects	Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands: UV	VIS	NIR	MIR	FIR	No. Boresight Cameras: BW	Col.	Col. IR	Total Flight Line Length (kilometers)
04May72	1330	GJGN	Local	1,3	–	7	4	–	1	4	–	1	26
12Nov71	1000	FHLQ,KQ-175	Houston, Texas	2,3,5	–	8	3	–	1	–	1	–	58
11Nov71	1300	FJJA,KA,FHKQ-175	Houston, Texas	5	–	8	3	–	1	–	1	–	50
11Nov71	1000	FHJQ,KQ-175	Houston, Texas	1,5	–	8	3	–	1	–	1	–	128
05Nov71	0800	GJFD-217	Forest Sites	10	–	8	3	–	1	–	1	–	32
04Nov71	1200	GJFD-217	Forest Sites	10	–	8	3	–	1	–	1	–	40
04Nov71	0800	GJFD-217	Forest Sites	10	–	8	3	–	1	–	1	–	40
03Nov71	1200	GJFD-217	Forest Sites	10	–	8	3	–	1	–	1	–	32
28Oct71	0930	GJGN-190	Ann Arbor, Michigan	1,2,5,10	–	8	3	–	1	1	–	–	38
06Oct71	0900	GJCJ,DJ,CH-277	Corn Blight	5	–	8	3	–	1	1	–	1	110
05Oct71	1230	GJCH,GJ,CK,DK-277	Corn Blight	5	–	8	3	–	1	1	–	1	123
05Oct71	0900	GJCJ,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	98
24Sep71	1300	GJCL,DL-277	Corn Blight	5	–	8	3	–	1	2	–	–	80
24Sep71	1130	GJCK,DK-277	Corn Blight	5	–	8	3	–	1	1	–	1	82
24Sep71	1130	GJCM,DM-277	Corn Blight	5	–	8	3	–	1	1	–	1	91
24Sep71	1000	GJCK,CL,DK,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	83
21Sep71	1400	GJFN	M.S.U. Agricultural Farm	1,4	–	8	3	–	1	1	–	1	43
18Sep71	1330	GJGP	Flint, Michigan	1,2,4	–	8	3	–	1	1	–	1	121
17Sep71	1830	GJGP	Flint, Michigan	1	–	–	–	–	1	–	–	–	49
17Sep71	1530	GJGP	Flint, Michigan	1	–	8	3	–	1	1	–	1	31
15Sep71	1645	GJGN-190	Ann Arbor, Michigan	1	–	8	1	–	2	–	–	–	1.6
15Sep71	1230	GHCH,CJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	74
15Sep71	1130	GJCK,DK-277	Corn Blight	5	–	8	3	–	1	1	–	1	82
15Sep71	0900	GJCJ,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	98
14Sep71	1300	GJCL,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	98
14Sep71	1130	GJCM,DM-277	Corn Blight	5	–	8	3	–	1	1	–	1	91
14Sep71	1000	GJCK,CL,DK,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	64
29Aug71	1330	GJDJ,DK-277	Corn Blight	5	–	8	3	–	1	1	–	1	29
29Aug71	1300	GJCL,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	80
29Aug71	1130	GJCM,DM-277	Corn Blight	5	–	8	3	–	1	1	–	1	101
28Aug71	1230	GJCH,CJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	74
28Aug71	1000	GJCK,CL,DK,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	82

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 6 of 7 Sheets

Flight Index: Date	Flight Index: Time	Site Description: Location	Site Description: Objects	Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands: UV	VIS	NIR	MIR	FIR	No. Boresight Cameras: BW	Col.	Col. IR	Total Flight Line Length (kilometers)
28Aug71	0900	GJCJ,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	98
26Aug71	1130	GJCK,DK-277	Corn Blight	5	–	8	3	1	1	1	–	1	83
17Aug71	1400	GJFN-282	M.S.U. Agricultural Farm	1,4	–	8	3	–	1	1	–	1	38
17Aug71	1130	GJCK,CL,CM,GJGN-277	Corn Blight	1,5	–	8	3	–	1	1	–	1	42
13Aug71	1300	GJCL,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	83
13Aug71	1130	GJCM,DM-277	Corn Blight	5	–	8	3	–	1	1	–	1	91
12Aug71	1230	GJCH,CJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	74
12Aug71	1130	GJCK,DK-277	Corn Blight	5	–	8	3	–	1	1	–	1	66
12Aug71	0900	GJCJ,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	101
11Aug71	1130	GJCK-277	Corn Blight	5	–	8	3	–	1	1	–	1	18
11Aug71	1000	GJCK,CL,DK,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	64
06Aug71	1400	GJFN-282	M.S.U. Agricultural Farm	5	–	8	3	–	1	1	–	1	104
06Aug71	0900	GJFN-282	M.S.U. Agricultural Farm	1,2,5	–	8	3	–	1	1	–	1	235
05Aug71	1300	GJCL,DL,CK-277	Corn Blight	5	–	8	3	–	1	1	–	1	64
31Jul71	1300	GJDL,DM-277	Corn Blight	5	–	8	3	–	1	1	–	1	56
31Jul71	1130	GJCL,DL,DM-277	Corn Blight	5	–	8	3	–	1	1	–	1	38
29Jul71	1130	GJCK,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	66
29Jul71	1000	GJCK,CL,DK,DL-277	Corn Blight	3,5	–	8	3	–	1	1	–	1	67
27Jul71	1230	GJCH,CJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	72
27Jul71	1130	GJCK,DK-277	Corn Blight	5	–	8	3	–	1	1	–	–	69
27Jul71	0900	GJCJ,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	98
21Jul71	1130	GJCK,DK-277	Corn Blight	5	–	8	3	–	1	1	–	1	118
16Jul71	1230	GJCH,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	77
16Jul71	1000	GJCK,CL,DK,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	67
16Jul71	0900	GJCJ,DJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	98
13Jul71	1130	GJCL,CM-277	Corn Blight	5	–	8	3	–	1	1	–	1	54
12Jul71	1300	GJCL,DL-277	Corn Blight	5	–	8	3	–	1	1	–	1	98
12Jul71	1130	GJCM,DM-277	Corn Blight	5	–	8	3	–	1	1	–	1	91
07Jul71	1400	GJFN-282	M.S.U. Agricultural Farm	1,4	–	8	3	–	1	2	–	1	38
07Jul71	0900	GJDJ,CL-277	Corn Blight	1,5	–	8	3	–	1	2	–	1	62
30Jun71	1230	GJCH,CJ-277	Corn Blight	5	–	8	3	–	1	1	–	1	91
30Jun71	0900	GJCJ,DJ-277	Corn Blight	3,5	–	8	3	–	1	2	–	1	98

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 8. M7 MULTISPECTRAL SCANNER FLIGHTS
(Continued)

Sheet 7 of 7 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
29Jun71	1130	GJCK,DK-277	Corn Blight	1,5	-	8	3	-	1	1	-	1	69
29Jun71	1000	GJCK,CL,DK,DL-277	Corn Blight	1,5	-	8	3	-	1	2	-	1	67
28Jun71	1300	GJCL,DL-277	Corn Blight	1,5	-	8	3	-	1	1	-	1	102
28Jun71	1130	GJCM,DM-277	Corn Blight	5	-	8	3	-	1	2	-	1	91

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 9. M5 MULTISPECTRAL SCANNER FLIGHTS

Sheet 1 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
17Sep71	1830	GJGP	Flint, Michigan	1	1	-	-	1	-	-	-	-	49
13Aug71	1130	GJCM,DM-277	Corn Blight	5	1	-	2	1	-	1	-	1	91
12Aug71	0900	GJCJ,DJ-277	Corn Blight	5	1	-	2	1	-	1	-	1	101
11Aug71	1000	GJCK,CL,DK,DL-277	Corn Blight	5	1	-	2	1	-	1	-	1	64
06Aug71	1400	GJFN-282	M.S.U. Agricultural Farm	5	1	-	2	1	-	1	-	1	104
06Aug71	0900	GJFN-282	M.S.U. Agricultural Farm	1,2,5	1	-	2	1	-	1	-	1	235
05Aug71	1130	GJDK,CM,DM-277	Corn Blight	5	1	-	2	1	-	1	-	1	67
31Jul71	1130	GJCL,DL,DM-277	Corn Blight	5	1	-	2	1	-	1	-	1	38
29Jul71	1130	GJCK,DJ-277	Corn Blight	5	1	-	2	1	-	1	-	1	66
29Jul71	1000	GJCK,CL,DL-277	Corn Blight	3,5	1	-	2	1	-	1	-	1	67
27Jul71	0900	GJCJ,DJ-277	Corn Blight	5	1	-	2	1	-	1	-	1	98
16Jul71	1000	GJCK,CL,DK,DL-277	Corn Blight	5	1	-	2	1	-	1	-	1	67
16Jul71	0900	GJCJ,DJ-277	Corn Blight	5	1	-	2	1	-	1	-	1	98
13Jul71	1130	GJCL,CM-277	Corn Blight	5	1	-	2	1	-	1	-	1	18
12Jul71	1130	GJCM,DM-277	Corn Blight	5	1	-	2	1	-	1	-	1	91
07Jul71	1400	GJFN-282	M.S.U. Agricultural Farm	1,4	1	-	2	1	-	2	-	1	38
07Jul71	0900	GJDJ,CL-277	Corn Blight	1,5	1	-	2	1	-	2	-	1	62
30Jun71	0900	GJCJ,DJ-277	Corn Blight	3,5	1	-	2	1	-	2	-	1	98
29Jun71	1000	GJCK,CL,DK,DL-277	Corn Blight	1,5	1	-	2	1	-	2	-	1	67
28Jun71	1300	GJCL,DL-277	Corn Blight	1	1	-	2	1	-	1	-	1	3
28Jun71	1130	GJCM,DM-277	Corn Blight	5	1	-	2	1	-	2	-	1	91
28May71	1600	GJDN,DM,DP-167	Cook Power Plant	7,10	1	7	3	-	2	1	1	1	117
28May71	0900	GJDN,DM,DP-167	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	128
22May71	1500	GJFN-282	M.S.U. Agricultural Farm	1,4	-	9	6	1	1	3	-	1	26
22May71	1130	GJDK,DJ,CJ-277	Corn Blight	5	-	9	6	1	1	2	-	1	98
22May71	1000	GJCJ,BJ,CJ,CH-277	Corn Blight	5	-	9	6	1	1	2	-		74
21May71	1130	GJCK,DK-277	Corn Blight	5	-	9	6	1	1	2	-	-	82
21May71	1000	GJCL,CK,DK-277	Corn Blight	5	-	9	6	1	1	2	-	1	64
17May71	1300	GJDM,CL,DL-277	Corn Blight	1,5	-	9	6	1	1	3	-	-	83
17May71	1130	GJDM,CM-277	Corn Blight	5	-	9	6	1	1	2	-	1	91
11May71	1200	GJLP	W Shore Lake Ontario	4,7,8	-	9	6	-	3	1	1	1	269
11May71	0400	GJLP	W Shore Lake Ontario	8	-	-	-	-	3	-	-	-	77

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 2 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
10May71	1330	GJMP,LP	NW Shore Lake Ontario	1,5	1	9	3	-	2	1	1	1	208
10May71	0900	GJLP	SW Shore Lake Ontario	5	1	9	3	-	2	1	1	1	55
07May71	0900	GJDN,DM,DP	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	128
05May71	0900	GJGN	Local Roads	1,2,5	1	9	6	-	1	1	1	1	92
30Apr71	1330	GJDN,DM,DP-167	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	31
30Apr71	0800	GJDN,DM,DP-167	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	95
23Apr71	1700	GJDN,DM,DP-167	Cook Power Plant	5,9,10	1	9	3	-	2	1	1	1	66
23Apr71	1330	GJDN,DM,DP-167	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	53
23Apr71	0900	GJDN,DM,DP-167	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	120
22Apr71	1830	GJDN,DM,DP-167	Cook Power Plant	5,10	1	-	-	-	2	-	-	-	53
22Apr71	1430	GJDN,DM,DP-167	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	61
22Apr71	0800	GJDN,DM,DP-167	Cook Power Plant	5,10	1	9	3	-	2	1	1	1	112
21Apr71	1400	GJGN	Test Flight	1,10	1	9	3	-	1	2	-	-	16
11Mar71	0900	GJFF,GF,FG	Map Diseased Trees	5,10	-	9	6	1	1	1	-	1	144
09Mar71	0400	FHKQ-175	Houston Area Test Sites	2,8	-	-	-	-	2	-	-	-	52
09Mar71	0000	FHKQ-175	Houston Area Test Sites	2,8	-	-	-	-	2	-	-	-	52
08Mar71	2000	FHKQ-175	Houston Area Test Sites	2,8	-	-	-	-	2	-	-	-	52
08Mar71	1600	FHKQ-175	Houston Area Test Sites	2,8	1	9	3	-	1	1	1	1	53
08Mar71	1200	FHKQ-175	Houston Area Test Sites	2,8	1	9	3	-	1	1	1	1	69
08Mar71	0800	FHKQ,LQ-175	Houston Area Test Sites	2,8	1	9	3	-	1	1	1	1	69
04Mar71	1100	FHKQ-175	Houston Area Test Sites	8	1	9	3	-	3	2	-	1	45
04Mar71	0550	FHHM-032	Agriculture	2,7	-	-	1	1	2	-	-	-	69
03Mar71	0550	FHHM-032	Agriculture	2,7	-	9	3	1	2	-	-	-	69
27Feb71	1300	FHHM-032	Agriculture	1,2	-	9	6	-	2	3	1	-	78
15Dec70	1000	GJMJ,MH	Highway Sites	1,2,5	-	9	6	-	1	2	1	1	58
14Dec70	2200	GJMJ,MH	Highway Sites	2,5	-	-	-	1	3	-	-	-	38
06Nov70	0830	GJQH,PH,PJ,QJ-252	Chesapeake Bay	1,2,5,10	1	9	5	-	1	2	1	1	184
05Nov70	1330	GJQH,PH,PJ,QJ-252	Chesapeake Bay	1,5,10	1	9	5	-	1	2	1	1	60
04Nov70	1400	GJQH,QJ,QK-252	Chesapeake Bay	1	1	9	5	-	1	2	1	1	10
30Oct70	0730	EJEF-002	Pisgah Crater	1,3	-	9	3	-	4	1	1	1	54
29Oct70	0800	EJEF-002	Pisgah Crater	1,3	1	9	3	-	4	1	1	1	42
28Oct70	1200	EJAD,AE	Oil Spill	2,4	1	9	6	-	1	1	1	1	29

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 9. M5 MULTISPECTRAL SCANNER FLIGHTS
(Continued)

Sheet 3 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
16Oct70	0900	GJGN,FN	Forest Sites	1,2,5,10	-	9	3	-	3	2	1	1	42
16Oct70	0600	GJGN	Forest Sites	2	-	2	-	-	4	-	-	-	14
16Oct70	0300	GJGN,FN	Forest Sites	2	-	-	-	-	4	-	-	-	22
16Oct70	0001	GJGN,FN	Forest Sites	2	-	-	-	-	3	-	-	-	14
01Oct70	1000	GJGN,FN	Forest Sites	1,2,3,6,10	-	9	6	-	3	1	1	1	76
29Sep70	0600	GJGN,FN	Forest Sites	1,2,3,6	-	9	6	-	3	1	-	1	34
23Sep70	1100	GJFF,GF,FG	Map Diseased Trees	1,2	-	9	6	1	1	2	1	1	18
21Sep70	0430	GHJP,JN,HN	Sink Holes, Water Pollution	2,10	-	-	-	-	4	-	-	-	98
20Sep70	0330	GNJP,JN	Sink Holes	2	-	-	-	-	4	-	-	-	149
19Sep70	0800	GHJP,JN,HN	Sink Holes, Water Pollution	2	1	9	6	-	1	2	1	1	112
18Sep70	0830	GHJP,JN,HN	Sink Holes, Water Pollution	1,10	1	9	6	-	1	2	1	1	183
11Sep70	1300	GJDL-250	Corn Blight	9	-	9	6	1	1	1	-	-	100
11Sep70	0900	GJDL-250	Corn Blight	3	-	9	6	1	1	1	-	-	67
09Sep70	0900	GJDP,EN,GP,GM,GKEA	Michigan Power Plants	3,5	-	9	3	-	4	1	1	-	
05Sep70	1400	GJDL-250	Corn Blight	6	-	9	6	1	1	1	-	-	99
05Sep70	0900	GJDL-250	Corn Blight	3	-	9	6	1	1	1	-	-	214
27Aug70	2000	HKEA-240	Catheart Mt., Maine	2,8	-	-	-	1	3	-	-	-	19
27Aug70	1000	HKEA-240	Catheart Mt., Maine	1,2	-	9	6	-	3	2	1	1	16
24Aug70	1630	GJDM,DL,DK,CK,CJ-277	Corn Blight	3	-	9	6	1	1	1	1	1	99
24Aug70	1100	GJDM,DK,DL,CK,CJ-277	Corn Blight	3	-	9	6	1	1	1	1	1	99
21Aug70	1030	GJGM	Agriculture	1,5	1	9	6	-	1	2	1	1	22
21Aug70	0730	GJGM	Agriculture	1,5,10	1	9	6	-	1	2	1	1	92
13Aug70	1430	GJDL,CL	Agriculture	1,2,3	-	9	6	1	1	1	2	1	208
11Aug70	1330	GJDL,CL	Agriculture	1,2,5	-	9	6	1	1	1	2	1	165
06Aug70	0130	GJGN,FN	Forest Sites	2,3	-	-	-	1	3	-	-	-	30
05Aug70	1000	GJGN,FN	Forest Sites	2,3,4,6,10	-	9	6	1	1	2	1	1	69
31Jul70	2330	FKFC,GC	Waterfowl Habitat	2,5	-	-	-	1	3	-	-	-	77
31Jul70	0930	FKFC,GC	Waterfowl Habitat	1,2,5	-	9	6	1	1	2	1	1	102
29Jul70	0900	EJQK	Forest Sites	1,3,5	-	9	6	1	1	1	-	2	30
28Jul70	1500	EJQK	Forest Sites	1,3	-	9	6	1	1	1	-	2	29
28Jul70	1100	EJQK	Forest Sites	1,3	-	9	6	1	1	1	-	2	29
28Jul70	0700	EJQK	Forest Sites	1,3	-	9	6	1	1	1	-	2	29

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 4 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
22Jul70	0700	GJGN,GM	Power Station,Cement Plant	1,2	-	9	3	2	2	2	-	-	16
21Jul70	1530	GJGN,GM	Power Station,Cement Plant	1,2	-	9	3	2	2	2	-	-	16
17Jul70	0900	GJEQ,GKEA	Nuclear Power Plant	2,5,6	1	9	3	-	2	1	1	1	240
17Jul70	0400	GKFA	Biological Station	1,2	-	-	-	1	2	-	-	-	24
16Jul70	1200	GKFA	Biological Station	1,2,10	1	9	6	-	1	1	1	1	34
13Jul70	1300	GJGN	Industrial Sites	1,2	-	9	3	2	1	1	1	-	43
07Jul70	0900	GJGN,FN	Forest Sites	2,3,6,10	-	9	6	1	1	2	1	1	53
06Jul70	1400	GJGN,GM,FN	Forest Sites	2,3,4,6,10	-	9	6	1	1	2	1	1	69
01Jul70	0930	GJDL,CL,CK,BL,AL	Agriculture	1,2,3,4,5, 10	-	9	6	1	1	2	1	1	219
01Jul70	0500	GJDL	Agriculture	5	-	-	-	1	3	-	-	-	38
30Jun70	0930	GJDL	Agriculture	1,2,3	-	9	6	1	1	2	1	1	168
26Jun70	0900	FJJE	Rock Outcrops, Soils	1,3,10	1	9	3	1	1	-	-	-	125
26Jun70	0500	FJJE	Rock Outcrops, Soils	1,3,10	-	-	-	1	3	-	-	-	88
25Jun70	0900	FJJE	Rock Outcrops, Soils	1,3,10	1	9	3	-	2	-	-	-	125
25Jun70	0500	FJJE	Rock Outcrops, Soils	1,3,7	-	-	-	1	2	-	-	-	89
24Jun70	1500	FJJE	Rock Outcrops, Soils	1,3,10	1	9	3	-	2	-	-	-	125
24Jun70	1200	FJJE	Rock Outcrops, Soils	1,3,10	1	9	3	-	2	-	-	-	125
23Jun70	1330	FJJE	Rock Outcrops, Soils	1,2	1	9	3	-	2	3	-	-	42
20Jun70	1030	GJGM	Agriculture	1,4	1	9	6	-	1	2	1	1	42
20Jun70	0730	GJGM	Agriculture	1,5,10	1	9	6	-	1	2	1	1	92
08Jun70	0700	GJGN,FN	Forest Sites	2,3,6,10	1	9	6	-	1	2	-	-	56
23May70	0930	FKKC,KB	Waterfowl Habitat	2,5,10	-	9	6	1	1	1	1	2	77
23May70	0030	FKFC,GC	Waterfowl Habitat	2,5	-	-	5	1	1	1	-	-	77
22May70	0900	FKFC,GC	Waterfowl Habitat	2,5	-	9	6	1	1	1	1	2	243
21May70	1530	FKFC,GC	Waterfowl Habitat	2,5	-	9	6	1	1	1	1	2	64
07May70	1400	GJDN,DM,DP-167	Cook Power Plant	1,5	-	9	3	1	3	3	-	-	62
06May70	1300	GJCL,DL,CK	Agriculture	1,2,5,6	-	9	6	1	1	1	1	1	248
06May70	0900	GJDL	Agriculture	1,2,3	-	9	8	1	1	1	1	1	198
08Apr70	1000	GJMJ,MH	Highway Site	2,5	-	9	6	1	1	2	-	1	38
07Apr70	2330	GJMJ,MH	Highway Site	2,5	-	-	2	1	1	-	-	-	38
04Apr70	1400	FJKJ,LK,KK	Highway Site	1,3,4	-	9	6	1	1	2	-	1	77

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 9. M5 MULTISPECTRAL SCANNER FLIGHTS
(Continued)

Sheet 5 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
26Mar70	2300	FJKK,LK,KJ	Highway Site	2,3	-	-	2	1	1	-	-	-	80
11Mar70	0830	GHKL-169	Pidgeon Key	1,2,7	-	9	6	1	-	1	1	1	83
10Mar70	0830	GHKL	Biscayne Bay	1,7	-	9	6	1	1	1	1	1	211
05Mar70	1100	GJGN	Local Test	1,2,10	-	8	6	1	1	3	-	-	70
17Dec69	1200	GJDL	Agriculture	3,5	-	7	6	1	1	1	1	1	373
26Nov69	1000	GJGN,GM,FN	Forest,Water Pollution	3,6,9	-	7	6	1	1	3	1	1	53
20Nov69	1000	GJGN,GJGM	Water Pollution	1	-	9	5	-	1	2	1	1	53
06Nov69	1100	GJDL	Agriculture	2,3,5	-	7	6	1	1	1	1	1	262
06Nov69	0830	GJDL	Agriculture	2,5	-	7	6	1	1	1	1	2	78
05Nov69	1300	GJDL	Agriculture	3	-	7	6	1	1	1	1	1	214
27Oct69	1030	EJCE	Smog Blighted Trees	1,3	-	7	5	1	1	2	1	1	14
27Oct69	0800	EJCE	Smog Blighted Trees	1,3	-	7	5	1	1	2	1	1	14
25Oct69	1330	EJCE	Smog Blighted Trees	1,2,3	-	7	5	1	1	2	1	1	19
24Oct69	1200	DJPR	Forest Sites	4,6	-	7	6	-	1	4	-	-	30
23Oct69	0530	EKAB,AC	Soils	2	-	-	-	3	1	-	-	-	56
22Oct69	1900	EKAB,AC	Soils	2,5	-	-	3	1	1	-	-	-	76
22Oct69	1430	EKAB,AC	Soils	2,5	-	7	6	1	1	1	1	1	76
22Oct69	0930	EKAB,AC	Soils	2	-	7	6	1	1	2	1	1	46
26Sep69	1030	DKPA	Diseased Trees	3	-	7	5	1	1	2	1	1	22
26Sep69	0730	DKPA	Diseased Trees	3	-	7	5	1	1	2	-	-	13
25Sep69	1000	EKAC,AB	Soils	2,3,8,10	-	7	5	1	1	1	1	1	61
24Sep69	1300	DJHQ,JQ,KQ,LQ,DJHP,JP,KP, LP-007	Oregon Coastal Waters	1	1	6	2	1	1	1	1	-	560
23Sep69	1330	DJ,LQ,DKLA,KA,JA,JB,KB,MA, LB,MB-007	Oregon Coastal Waters	1	1	7	2	1	1	1	1	-	520
23Sep69	0900	DJLQ,DKLA,KA,JA,JB,KB,MA, LB,MB-007	Oregon Coastal Waters	1	1	7	2	1	1	1	1	-	120
21Sep69	1000	DJHPJP,KP,LP,DJHN,JN,KN, LN-007	Oregon Coastal Waters	1	1	7	2	1	1	1	1	-	400
15Sep69	1500	DJHQ,JQ,KQ,DJHP,JP,KP, LN-007	Oregon Coastal Waters	1	1	7	2	1	1	1	1	-	400

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 6 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
15Sep69	1045	DJHP,JP,KP,LP,DJHN,JN,KN, LN-007	Oregon Coastal Waters	2	1	7	4	1	1	1	1	-	408
14Sep69	0900	DJHQ,JQ,KQ,LQ, DJHP,JP,KP LP-007	Oregon Coastal Waters	2	1	6	4	1	1	1	1	-	406
03Sep69	1100	GJGN	Agriculture	1,2,5,10	-	7	5	1	1	-	1	1	64
03Sep69	0715	GJGN	Agriculture	1,2,5,10	-	7	5	1	1	-	1	1	58
13Aug69	2100	GJGN,FN	Forest Sites	2,3,6,9	-	-	-	1	1	-	-	-	59
13Aug69	2100	GJGN,GM	Water Pollution	1	-	-	-	2	1	-	-	-	53
13Aug69	0900	GJGN,FN	Forest Sites	2,3,6,9	-	7	5	1	1	3	2	1	59
13Aug69	0900	GJGN,GM	Water Pollution	1	-	9	5	1	1	3	2	-	53
11Aug69	0930	GJDN,DM,DP-167	Cook Power Plant	5	1	7	2	1	1	3	1	1	269
06Aug69	1030	GJDL	Agriculture	3	-	7	5	1	1	3	1	1	214
05Aug69	1030	GJDL	Agriculture	5	-	7	5	1	1	3	1	1	214
05Aug69	0700	GJDL	Agriculture	5	-	7	5	1	1	3	1	1	110
04Aug69	0930	GJGN,FN	Forest Sites	1,2,3,4,9	-	7	5	1	1	3	1	1	42
23Jul69	0245	FKEB,EC,DC	Water Pollution	1,4	-	-	-	2	1	-	-	-	230
22Jul69	1230	FJBQ	Diseased Trees	2,5,8	-	7	5	1	1	3	1	1	38
22Jul69	0830	FJBQ	Diseased Trees	2,5,8	-	7	5	1	1	3	1	1	43
21Jul69	1430	FJBQ	Diseased Trees	2,5,8	-	7	5	1	1	3	1	1	38
21Jul69	1030	FJBQ	Diseased Trees	2,5,8	-	7	5	1	1	3	1	1	34
16Jul69	1000	DJPK	Forest Sites	3,6	-	7	5	1	1	2	1	1	45
15Jul69	1030	DKPA	Diseased Trees	2	-	7	5	1	1	2	1	1	26
15Jul69	0630	DKPA	Diseased Trees	2	-	7	5	1	1	-	-	-	22
14Jul69	1330	DKPA	Diseased Trees	2	-	7	5	1	1	2	1	1	22
14Jul69	0800	DKPA	Oregon Coastal Waters	2	-	7	5	1	1	-	-	-	26
12Jul69	1500	DJLQ,DKLA,MA,LB,MB-007	Oregon Coastal Waters	1	-	6	4	1	2	2	1	-	448
12Jul69	0900	DJLQ,LP,LN,LM-007	Oregon Coastal Waters	1	-	6	2	1	2	2	1	-	480
08Jul69	1130	DJLQ,DKLA,KAJA,JB,KB,MA,LB, MB-007	Oregon Coastal Waters	1	-	6	4	1	2	2	1	-	560
06Jul69	1130	DJHQ,JQ,KQ,LQ,DJHP,JP,KP, LP-007	Oregon Coastal Waters	1,3	-	6	4	1	1	2	-	-	395
05Jul69	1430	DJLM,LN,LP,LQ-007	Oregon Coastal Waters	1	-	6	2	1	2	1	1	-	560

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 9. M5 MULTISPECTRAL SCANNER FLIGHTS
(Continued)

Sheet 7 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
05Jul69	0900	DJLQ,DKLA,MA,LB,MB-007	Oregon Coastal Waters	1	-	6	4	1	2	1	1	-	560
03Jul69	1400	DJHP,JP,KP,LP,DJHN,JN,KN, LN-007	Oregon Coastal Waters	1	-	6	4	1	2	1	1	-	600
26Jun69	1030	GJDL	Agriculture	5	-	7	5	1	1	2	1	1	189
25Jun69	1700	GJDL	Agriculture	5	-	7	5	1	1	2	1	1	227
25Jun69	1100	GJDL	Agriculture	2	-	7	5	1	-	2	1	1	138
27May69	1330	GJDP-167	Cook Power Plant	3	-	9	6	1	1	1	1	-	43
27May69	1100	GJDL	Agriculture	2,5	-	7	5	1	1	3	1	1	187
26May69	1100	GJDL	Agriculture	4	-	7	5	1	1	3	1	1	154
15May69	2100	GJPL	Highway Site	3	-	6	1	3	1	-	-	-	109
15May69	1200	GJPL	Highway Site	3	-	8	5	1	1	3	1	1	106
13May69	0800	GJDL	Agriculture	5	-	7	5	1	1	3	1	1	139
12May69	0945	GJGN	Local Test	2	-	7	5	1	1	7	-	-	29
12Mar69	0900	EJDC,EC,DD,EJCC	San Diego & Sultan Sea	1,2,5,10	-	7	5	1	1	3	1	1	168
08Mar69	1100	EJDE,EJEC,EJDD	San Diego & Sultan Sea	2,10	-	7	5	1	1	3	1	1	77
07Mar69	1130	EJAE	Oil Spill	2,10	-	8	5	1	2	3	3	1	150
07Mar69	0615	EJAE	Oil Spill	2,10	1	8	5	1	1	3	3	1	166
06Mar69	1500	EJAE	Oil Spill	2,10	-	7	5	1	1	3	3	1	154
26Feb69	1100	GJGN	Water Pollution	1	-	7	5	1	1	3	-	1	51
21Oct68	1030	GJGN	Local Test	2,3	-	7	6	1	1	2	1	1	33
15Oct68	1000	GJFF,GF	Bull Run Power Plant	4,10	-	7	6	1	1	-	1	3	168
26Sep68	1400	GJDM,GN	Agriculture	1,3,4	-	7	6	1	1	1	2	1	29
26Sep68	0900	GJDL-167	Cook Power Plant	5,10	-	7	6	1	1	1	2	1	146
23Sep68	0900	EJBH,BJ,AJ,AH	Rock Outcrops, Faults	4	-	7	5	2	2	2	1	1	80
20Sep68	0900	EJPK,PJ	Forest Sites, Agriculture	4,5,10	-	7	6	1	1	2	1	1	192
17Sep68	0800	FJAL	Soil, Grassland Sites	2,5	-	7	6	1	1	2	1	1	230
09Sep68	1330	GJGN	Test Flight	1,2,5,10	-	7	6	1	1	2	-	-	29
22Aug68	1450	GJGN	Detroit River	2	-	7	5	1	-	2	-	-	26
22Aug68	1000	GJGN	Agriculture	1,2,5,10	-	7	6	1	1	1	1	1	117
30Jul68	0900	GJDL	Agriculture	1,5	-	7	6	1	1	2	1	1	75
25Jul68	0900	GJGN	Agriculture	1,2,5,10	-	7	6	1	1	2	1	1	91
31May68	0730	FKFC,GC	Waterfowl Habitat	2,10	-	7	6	1	1	2	1	1	123

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 8 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
30May68	0730	FJBQ	Diseased Trees	1	-	7	6	1	1	-	-	-	22
29May68	1400	FJBQ	Diseased Trees	1	-	7	6	1	1	1	-	-	22
29May68	1130	FJBQ	Diseased Trees	1	-	7	6	1	1	2	1	1	19
29May68	0830	FJBQ	Diseased Trees	1	-	7	6	1	1	-	-	-	22
22May68	1000	GJGN	Test Flight	1,2,10	-	7	6	1	1	4	-	-	86
08Nov67	1000	GJGN	Local Test	1,2	-	7	6	-	-	2	1	1	74
16Oct67	1000	BLJM	Heat Flow and Sea Ice	2,6,10	-	9	3	1	1	2	1	1	250
16Oct67	0530	BLJM	Heat Flow and Sea Ice	2	-	9	3	1	1	-	-	-	147
12Oct67	0530	BLJM	Heat Flow and Sea Ice	1	-	-	-	1	1	-	-	-	32
11Oct67	1630	BLJM	Heat Flow and Sea Ice	2	-	9	3	1	1	2	1	1	115
10Oct67	1430	BLJM	Heat Flow and Sea Ice	1	-	9	3	1	1	2	1	1	125
10Oct67	1000	BLJM	Heat Flow and Sea Ice	1	-	9	3	1	1	2	1	1	147
03Oct67	1400	BLJM	Heat Flow and Sea Ice	2,10	-	9	6	1	1	2	1	1	154
03Oct67	0900	BLJM	Heat Flow and Sea Ice	2	-	9	6	1	1	2	1	1	48
30Sep67	1400	BLJM	Heat Flow and Sea Ice	1,2	1	9	3	1	1	2	1	1	109
30Sep67	0900	BLJM	Heat Flow and Sea Ice	2	-	9	3	1	1	2	1	1	109
22Sep67	0500	EJKQ	Geothermal Areas	11	1	9	3	1	1	2	1	1	162
21Sep67	1900	EJKQ	Geothermal Areas	11	-	-	-	1	1	-	-	-	112
20Sep67	2200	EJKQ	Geothermal Areas	11	-	-	-	1	1	-	-	-	115
20Sep67	0200	EJKQ	Geothermal Areas	11	-	-	-	1	1	-	-	-	79
19Sep67	1400	EJKQ	Geothermal Areas	11	1	9	5	1	1	2	1	1	125
07Sep67	0730	GHKL	Coastal Waters	2,5,10	-	7	6	1	1	-	-	1	123
06Sep67	0400	GHHN,JN	Water Pollution, Agric.	2,5	-	-	2	1	1	-	-	-	27
05Sep67	1200	GHHN, JN	Water Pollution, Agric.	2	1	9	6	1	1	2	1	1	30
04Sep67	1130	GJHF	Asheville, NC	4	1	9	3	1	-	2	1	1	5
04Sep67	0630	GJHG	TVA Dams, Clinch River	4	-	7	6	1	1	2	1	1	104
03Sep67	1300	GJHG	TVA Dams, Clinch River	3,4	-	7	6	1	1	2	1	1	94
03Sep67	0900	GJHG	TVA Dams, Clinch River	4	-	7	6	1	1	2	1	1	60
23Sep67	1300	GJGN	Test Flight	2	1	9	6	1	1	3	-	-	38
06Jul67	1000	GJGN,GJHN, GJGM	Water Pollution	2,10	1	9	3	1	1	2	-	-	326
27Jun67	1300	GJGN	Test Flight	1,2,3	1	9	3	1	1	2	-	-	38
28Apr67	0900	GJDK	Highway Site	2,3	1	9	3	1	1	2	-	-	224

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 9. M5 MULTISPECTRAL SCANNER FLIGHTS
(Continued)

Sheet 9 of 10 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
15Mar67	1000	GJGN	Test Flight	1,2,4	1	9	3	-	1	2	1	1	61
14Mar67	1000	GJGN	Test Flight	1,2	1	9	3	-	1	2	1	1	
02Mar67	1000	GJGN	Test Flight	1,2,4	1	9	3	-	1	4	-	-	45
15Dec66	1330	GJGN, GJGM	Local, Detroit River	1,2	1	-	-	1	1	2	-	-	75
22Nov66	1400	GJGN	Botanical Gardens	1,2,3,4	1	9	3	1	1	1	1	-	32
18Nov66	1300	GJGN, GJGM	Water Pollution	1,2	1	9	3	1	1	2	-	-	117
14Nov66	1330	GJGN, GJGM	Local, Detroit River	1,2	1	9	4	1	1	1	1	-	83
15Sep66	2030	GJDL-044	Livestock, Agriculture	1,2,10	-	-	-	1	1	-	-	-	80
15Sep66	1200	GJDL-044	Agriculture	1,2,4	1	9	5	2	1	2	1	1	94
15Sep66	0730	GJDL	Agriculture	1,2,4,6,8 10	1	9	5	2	1	2	1	1	137
01Sep66	1300	GJGN	Forest Site	1,2	1	9	5	2	1	2	-	-	19
30Aug66	1000	GJGN	Local Test	1,2,10	1	9	5	2	1	2	1	1	70
25Aug66	1000	GJGN	Local Test	1,2	1	9	5	2	1	2	1	-	32
29Jul66	0800	GJDL	Agriculture	1,2,4	-	9	5	2	-	2	1	-	64
28Jul66	1200	GJDL	Agriculture	1,2	-	9	5	2	-	2	1	1	64
27Jul66	0815	GJDL	Livestock, Agriculture	1,2,4	-	9	5	2	1	2	1	1	64
26Jul66	2130	GJDL	Livestock, Agriculture	1,2,10	-	-	-	1	1	-	-	-	58
26Jul66	1000	GJDL	Agriculture	2,4,6,8,9	1	9	5	2	1	2	1	1	121
21Jul66	1200	GJGN	Local Test	1,2,10	1	9	5	2	1	2	1	1	110
30Jun66	1400	GJDL	Agriculture	1,2,4	1	9	5	2	1	2	1	1	96
30Jun66	0830	GJDL	Agriculture	2,10	1	9	5	2	1	2	1	1	32
29Jun66	2130	GJDL	Livestock, Agriculture	1,2,10	-	-	-	1	1	-	-	-	21
28Jun66	1000	GJDL	Livestock, Agriculture	2,3	1	9	5	2	1	2	1	1	50
24Jun66	1100	GJGN	Local Test	1,2	1	-	2	2	1	-	-	-	32
02Jun66	1000	FHGM	Agriculture	2	1	9	5	2	1	2	1	1	24
01Jun66	1800	FHGM	Agriculture	2	1	9	5	2	1	1	-	-	91
01Jun66	1330	FHGM	Agriculture	2,4,7,10	1	9	5	2	1	1	1	1	72
01Jun66	0500	FHGM	Agriculture	2	-	-	2	2	1	-	-	-	67
31May66	1000	FHHM	Agriculture	2,10	1	9	5	2	1	1	1	1	64
30May66	1430	FHGM	Agriculture	2	1	9	5	2	1	1	1	1	64
26May66	1330	DJPH, DJPJ	Hayward Fault, Agric.	2	1	9	5	2	1	2	1	1	37

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

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Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
25May66	1400	EJBK	Faults Zone	2,5	1	9	5	2	1	2	1	1	70
25May66	1200	EJBK	Faults Zone	1,2,4	1	9	5	2	1	2	1	1	102
24May66	1000	EJBH, BJ, AJ, AH, DJ, PH, EJAH	Agric., Mono Lake, Yosemite	2,5,7	1	9	5	2	1	2	1	1	76
24May66	0530	DJPH, DJPJ	Agriculture	2	-	-	1	2	1	-	-	-	35
20May66	0445	DJPK	Forest Sites	2	1	9	5	2	1	1	-	-	107
19May66	1400	DJPK, DJPL	Forest Sites	2	1	9	5	2	1	2	1	1	87
19May66	1000	EJAP	Northern California	1,4	1	9	5	2	1	2	1	1	86
18May66	1000	EJBK, DJPL	Northern California	2	1	9	5	2	1	2	1	1	80
17May66	1330	DJPH, DJPJ	Northern California	2	1	9	5	2	1	2	1	1	74
06May66	1330	GJDL	Agriculture	4	1	9	5	2	1	2	1	1	250
05May66	1300	GJDL	Agriculture	4	1	9	5	2	1	2	1	1	154
04May66	1330	GJGM	Test Flight	1,2,4	1	9	5	2	1	4	-	-	64
04May66	1000	GJGN	Local	5	1	-	2	2	1	4	-	-	64
29Apr66	1300	GJGM	Lake Erie	2	1	9	5	2	1	4	-	-	32
28Apr66	1000	GJGN	Lake Erie	2,5	1	9	5	2	1	4	-	-	32
21Mar66	1400	GJGN	Test Flight	1,2	1	-	3	-	-	2	-	-	32
14Mar66	1000	GJGN	Test Flight	1,2	1	-	1	1	1	1	-	-	32
11Mar66	1000	GJGN	Test Flight	1,2	1	-	1	1	1	-	-	-	32
02Feb66	1400	GJGN	Local	2	-	-	1	1	1	1	-	-	64
06Jan66	1000	GJGN	Local	2,4	-	-	1	1	1	2	-	-	18

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 10. M1A1 THERMAL SCANNER FLIGHTS

Sheet 1 of 2 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
28Jan71	2330	HHJD	S Puerto Rico Shoreline	5,10	-	-	-	1	-	-	-	-	280
19Jan71	2330	HHJD	St. Croix Shoreline	1,5	-	-	-	1	-	-	-	-	140
19Jan71	0015	HHJE	San Juan Shoreline	5,10	-	-	-	1	-	-	-	-	560
05Dec70	1830	EJCG	Rogers Dry Lake	10,15	-	-	-	1	-	-	-	-	770
03Dec70	0230	EJCG	Harpers Dry Lake	5,15	-	-	-	1	-	-	-	-	560
01Dec70	1945	EJCG	Harpers Dry Lake	5,15	-	-	-	1	-	-	-	-	280
18Nov70	2130	HJEN	Massachusetts Shoreline	5,10	-	-	-	1	-	-	-	-	210
17Nov70	2130	HJGQ	Maine Shoreline	5,12	-	-	-	1	-	-	-	-	630
22Jul70	2000	EJCG	S California Dry Lakes	10	-	-	-	1	-	-	-	-	210
19Jul70	2100	DKNN	Mountain Peaks	10	-	-	-	1	-	-	-	-	420
18Jul70	2100	DKPB	Mountain Peaks	10	-	-	-	1	-	-	-	-	280
14Jul70	2130	DKPA	Mountain Peaks	10	-	-	-	1	-	-	-	-	70
01May69	2145	HJEM	Cape Cod Shoreline	12	-	-	-	1	-	-	-	-	1120
30Apr69	2200	HJGQ	Penobscot Shoreline	6,12	-	-	-	1	-	-	-	-	1190
09Apr69	2015	EJKQ	Thermal Anomalies	5	-	-	-	1	-	-	-	-	980
11Jan69	0335	EJBJ	Spring Mountain	5	-	-	-	1	-	-	-	-	840
10Jan69	0635	EJBJ-003	Mono Crater	3	-	-	-	1	-	-	-	-	140
18Dec68	1920	HHJE	Soils & Caves	3,4	-	-	-	1	-	-	-	-	140
17Dec68	1905	HHJE	Soils & Caves	3,6	-	-	-	1	-	-	-	-	140
17Dec68	0900	HHJE	Soils & Caves	6	-	-	-	1	-	unknown			140
16Dec68	0845	HHJE	El Yunque	3,12	-	-	-	1	-	unknown			140
15Dec68	0900	HHJE	Punta Picua	6	-	-	-	1	-	unknown			70
14Dec68	0930	HHHE	Mayaquez	6	-	-	-	1	-	unknown			70
13Dec68	0900	HHJE	Salinas	3	-	-	-	1	-	unknown			140
06Dec68	1905	HHJE	Puerto Rico	2	-	-	-	1	-	-	-	-	280
03Dec68	0835	HHJE	Punta Picua	1,3	-	-	-	1	-	unknown			210
03Dec68	0430	HHJE	Punta Picua	1,3	-	-	-	1	-	-	-	-	140
01Dec68	1850	HHJE	Punta Picua	1,3	-	-	-	1	-	unknown			140
01Dec68	1240	HHJE	Punta Picua	3,6	-	-	-	1	-	unknown			70
25Nov68	1840	HHJE	Punta Picua	3	-	-	-	1	-	-	-	-	140
24Nov68	1930	HHJD	Ponce St. Croix	1,2	-	-	-	1	-	-	-	-	70
22Nov68	0840	HHJE	Punta Picua	5,6	-	-	-	1	-	unknown			140

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 2 of 2 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Scanner Spectral Bands					No. Boresight Cameras			Total Flight Line Length (kilometers)
Date	Time	Location	Objects		UV	VIS	NIR	MIR	FIR	BW	Col.	Col. IR	
21Nov68	0910	HHJE	Puerto Rico	4,5	-	-	-	1	-	unknown			70
01Nov68	1950	LL	Surtsey Volcano	1,25	-	-	-	1	-	-	-	-	140
26Oct68	2040	LL	Surtsey Volcano	10,18	-	-	-	1	-	-	-	-	210
23Oct68	2133	LL	Surtsey Volcano	1,12	-	-	-	1	-	-	-	-	420
22Oct68	2015	LL	Surtsey Volcano	1	-	-	-	1	-	-	-	-	70
19Oct68	2200	LL	Surtsey Volcano	1,13	-	-	-	1	-	-	-	-	140

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

TABLE 11. SLAR X-L BAND RADAR FLIGHTS

Sheet 1 of 2 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Radar Imagery Bands				No. Boresight Cameras			Total Flight Line Length (kilometers)
					X		L					
Date	Time	Location	Objects		P	C	P	C	BW	Col.	Col. IR	
18Apr74	0823	GJGD	A.E.S.	10	1	1	1	1	-	-	-	8
05Apr74	1400	EJHD	Soil Moisture	10	1	1	1	1	-	-	-	260
03Apr74	0925	EJHD	Soil Moisture	10	1	1	1	1	-	-	-	96
13Mar74	1000	GKFB	Lake Ice	10	1	1	1	1	-	-	-	305
12Oct73	0910	GHKP	Merritt Island	10	1	1	1	1	-	-	-	15
07Oct73	0635	GHKP	Brevard County	10	1	1	1	1	-	-	-	175
05Oct73	1227	GJGK	Flooding, Mining	10	1	1	1	1	-	-	-	500
03Oct73	1454	GJEL	Agriculture	10	1	1	1	1	-	-	-	100
13Sep73	0955	GJEL	Agriculture	10	1	1	1	1	-	-	-	60
05Apr73	0930	GJGN	Flooding, Land Use	10	1	1	1	1	-	-	-	60
28Mar73	1033	GJGN	Flooding, Land Use	10	1	1	1	1	1	-	-	100
13Aug72	1105	GJFD	Sweat Mountain	10	1	-	-	-	1	-	-	160
19May72	0835	GJEE	Sweat Mountain	10	1	-	-	-	1	-	-	50
18May72	0800	GHJP	Orlando Area	10	1	-	-	-	1	-	-	120
17May72	0800	GHJP	Orlando Area	10	1	-	-	-	1	-	-	[illegible]
25Apr72	0825	FHKQ	Houston Area	10	1	-	-	-	1	-	-	100
23Apr72	0925	FHKQ	Houston Area	10	1	-	-	-	1	-	-	100
22Apr72	0720	FHKQ	Houston Area	10	1	-	-	-	1	-	-	100
17Apr72	1050	FHKQ	Houston Area	10	1	-	-	-	1	-	-	100
08Oct71	0715	EJBH-003	Mono Crater	10	1	1	-	-	-	-	-	60
05Oct71	0707	EJBH-003	Mono Crater	10	1	1	1	1	-	-	-	70
04Oct71	1018	EJBH-003	Mono Crater	10	-	-	1	1	-	-	-	60
03Oct71	0732	EJDE-002	Pisgah Crater	10	1	1	1	1	-	-	-	70
02Oct71	0650	EJDE-002	Pisgah Crater	10	1	1	-	-	-	-	-	70
01Oct71	0957	EJDE-002	Pisgah Crater	10	1	1	-	-	-	-	-	50
31Aug71	1130	EJDE-002	Pisgah Crater	10	1	1	1	1	1	-	-	60
27Aug71	0715	EJDE-002	Pisgah Crater	10	-	-	1	1	1	-	-	50
24Aug71	0540	EJDE-002	Pisgah Crater	10	-	-	1	1	1	-	-	30
21Aug71	0655	FJEJ-076	Agriculture	10	1	1	1	1	1	-	-	50
23Jul71	0715	FJEJ-076	Agriculture	10	1	1	1	1	1	-	-	40
22Jul71	0653	FJEJ-076	Agriculture	10	1	1	1	1	1	-	-	40
22Jun71	0515	GJLP	Escarpments	10	1	-	-	-	1	-	-	50

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

Sheet 2 of 2 Sheets

Flight Index		Site Description		Nominal Spatial Resolution (meters)	No. of Radar Imagery Bands				No. Boresight Cameras			Total Flight Line Length (kilometers)
					X		L					
Date	Time	Location	Objects		P	C	P	C	BW	Col.	Col. IR	
04Oct69	0800	FJEJ, H	Agriculture	10	1	1	-	-	1	-	-	90
02Oct69	0745	FJHE	Tuskahomo Syncline	10	1	1	-	-	1	-	-	50
01Oct69	0800	FJHE	Agriculture	10	1	1	-	-	-	-	-	50
26Sep69	0805	FJKJ	Agriculture	10	1	1	-	-	1	-	-	70
24Sep69	0940	FJKJ	Agriculture	10	1	1	-	-	-	-	-	20
05Apr68		GKFB	Ice	10	1	-	-	-	-	-	-	30
29Mar68		GKFB	Ice	10	1	-	-	-	-	-	-	30

NOTE: (1) For list of published documents which use airborne sensor data collected by ERIM, see Appendix A.
(2) For geographic reference system, see Appendix B.
(3) For list of organizational addresses, see Appendix C.

4
DESCRIPTION OF ERIM AIRBORNE SENSOR SYSTEMS

In order to interpret the sensor imagery properly, it is necessary to know the sensors' functions and performance characteristics. Therefore, these items are discussed briefly in the following descriptions of each airborne sensor system.

4.1 M7 MULTISPECTRAL SCANNER

TheM7 scanner, covering a wavelength range from 0.33 to 14.0 μm, can operate in up to 19 different spectral bands of the ultraviolet, visible, and infrared regions (see Table 12). Of these bands, 12 are selected for tape recording at any one time on a 14-track magnetic tape machine. As many as five separate radiation reference sources are recorded sequentially for calibration purposes along with the ground video once in each scan line.

The simplified diagrams of Figure 32 illustrate a typical line scanner and its method of airborne use. As shown in the optical schematic at the top of the figure, the scanner basically consists of an optical telescope with its narrow field of view redirected by a rotating flat mirror. This mirror causes the system to scan in a plane perpendicular to the longitudinal axis of the aircraft. A radiation detector in the focal plane of the telescope converts the focused beam of radiation to an electrical signal. First,the optical system's instantaneous field of view (ground resolution element) scans laterally across the aircraft ground track through an opening in the bottom of the aircraft. Then, before making the next ground scan, it scans radiation references (not shown) which are internal to the scanner. By the time the next scan begins the aircraft has moved forward, so that subsequent line scans build upon one another to produce a continuous strip image of the terrain beneath the aircraft.

The multispectral scanner evolved from this single-channel scanner concept. This evolution required replacement of the single detector element with a system of beamsplitters, dispersing optics, spectral filters, and multiple detection elements. Figure 33 shows the optical configuration of the M7 multispectral scanner. The radiation intercepted by the 5-inch-diameter collecting aperture is directed into the Dall-Kirkham telescope, which has a 3-inch-diameter secondary mirror. The incoming radiation prevented from entering the telescope by this secondary mirror is directed upward by a folding mirror to Detector Position 1. This 3-inch-diameter collecting aperture operates over the broad band of 0.3 to 14.0 μm. To provide thermal data at this position, a focusing lens designed for the 8.0 to 14.0 μm band is used in combination with a cooled HgCdTe detector. A dichroic mirror mounted ahead of this lens diverts ultraviolet and visible radiation onto a photomultiplier detector which is filtered so that the energy it receives for recording is restricted to a narrow pre-selected band.

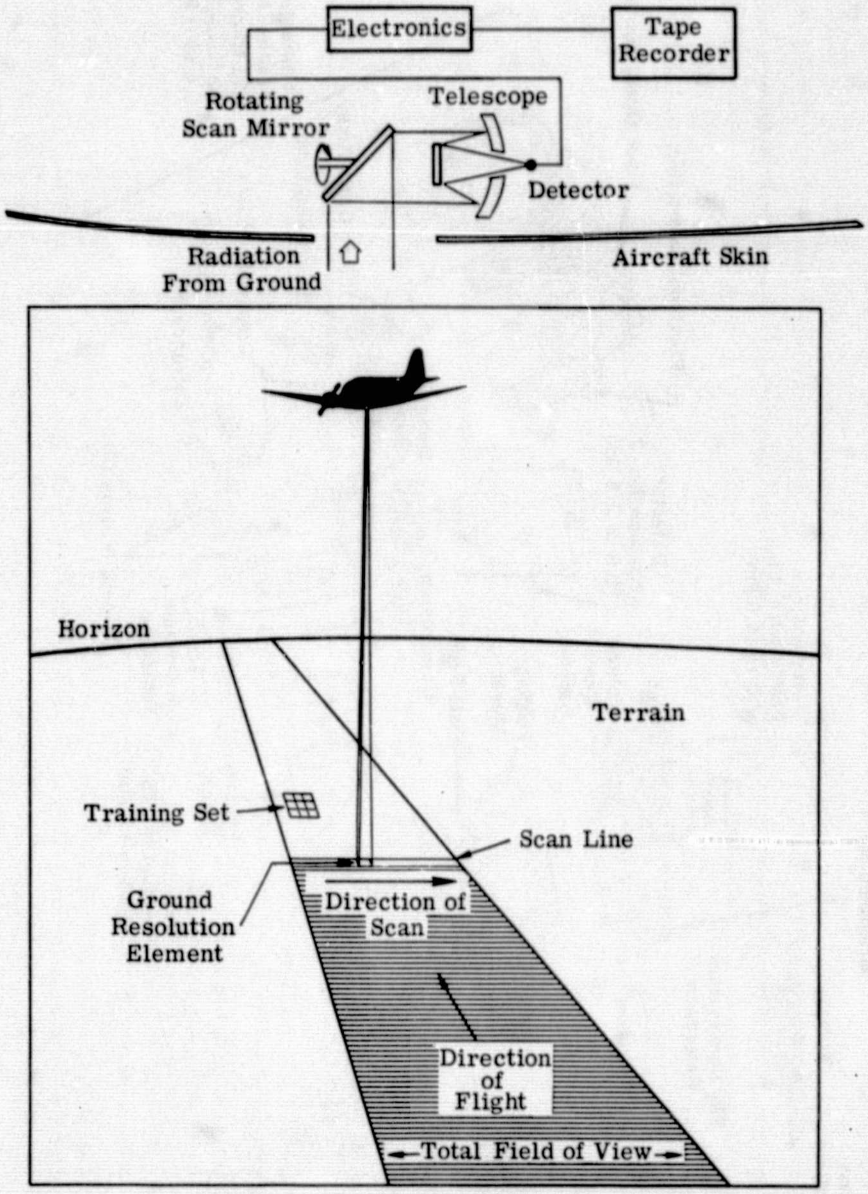

FIGURE 32. AIRBORNE MULTISPECTRAL SCANNER OPERATION

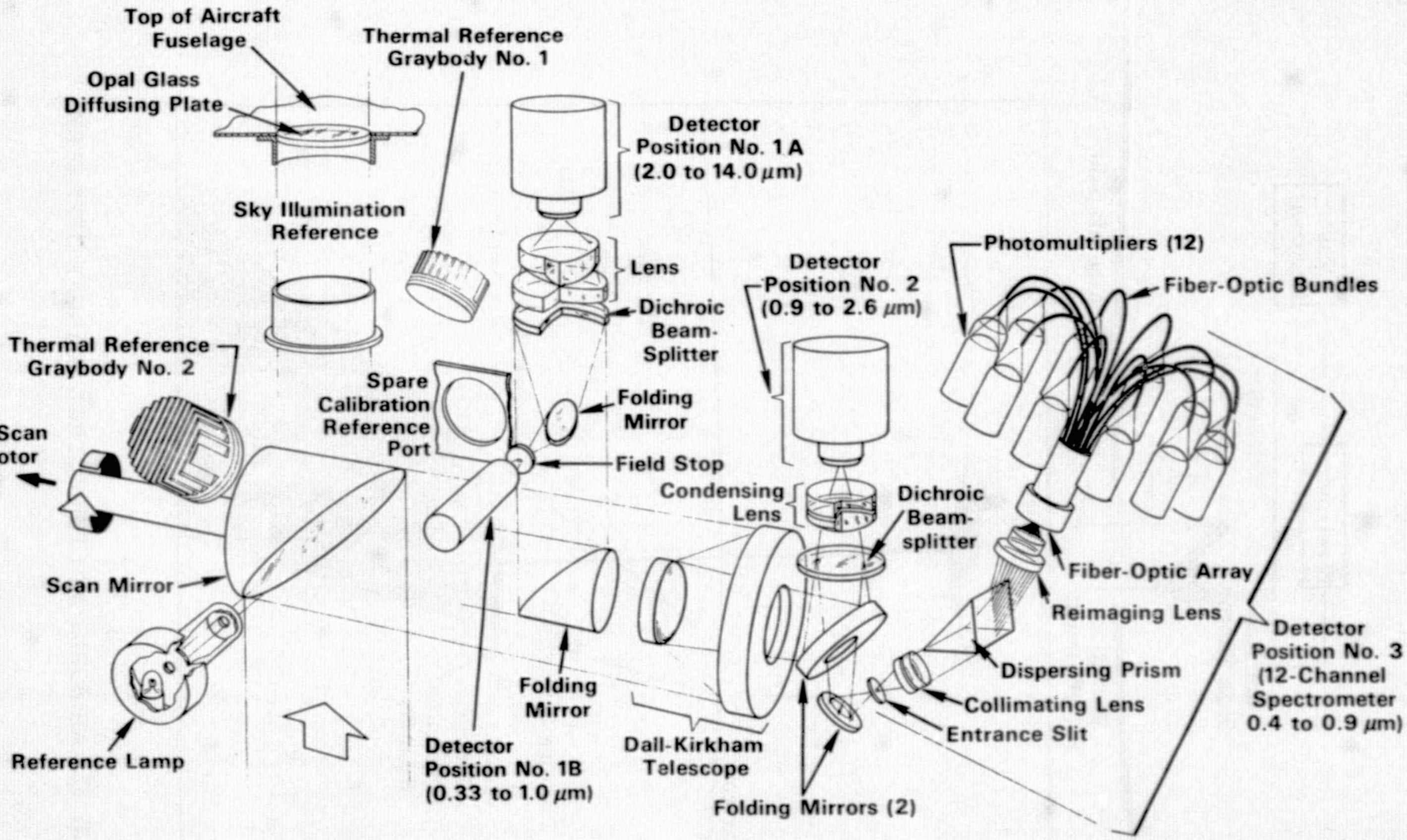

FIGURE 33. OPTICAL SCHEMATIC OF ERIM EXPERIMENTAL MULTISPECTRAL SCANNER, M7

TABLE 12. TYPICAL SPECTRAL BANDS AVAILABLE IN THE M5 AND M7 MULTISPECTRAL SCANNERS

Wavelength (μm)	Color
0.33-0.38	ultraviolet
0.40-0.44	violet
0.44-0.46	violet blue
0.46-0.48	blue
0.48-0.50	blue green
0.50-0.52	green
0.52-0.55	yellow green
0.55-0.58	yellow
0.58-0.62	orange
0.62-0.66	orange red
0.66-0.72	red
0.72-0.80	infrared (NIR)
0.80-1.00	infrared (NIR)
1.0-1.4	infrared (NIR)
1.5-1.8	infrared (NIR)
2.0-2.6	infrared (NIR)
*4.5-5.5	infrared (MIR)
8.0-14.0	infrared (FIR)
9.3-11.7	infrared (FIR)
10.5-12.4	infrared (FIR)

*Not available in the M7 scanner until 1975.

The radiation collected by the effective 4-inch aperture of the Dall-Kirkham telescope is folded into a dichroic mirror which reflects radiation below 1.0 μm, but transmits that of longer wavelengths. The radiation thus transmitted is focused onto three separately filtered indium-arsenide detector elements in Position 2 by a lens achromatized for the 1.0 to 2.6 μm region. This dichroic and lens can be readily changed for different detector configurations such as a second thermal infrared detector at this position.

Radiation at wavelengths shorter than 1.0 μm is focused onto the entrance slit of a prism spectrometer at Detector Position 3. The spectrometer divides and directs visible and near-infrared radiation through a fiber-optic image slicer to as many as twelve photomultiplier tubes.

The radiation reference sources are positioned in line with the scan mirror, so that each source is "seen" and registered sequentially once each scan line. Five reference sources are used: an NBS lamp packaged to simulate a point source; one ambient and two temperature-controlled graybody thermal references that fill the collecting aperture; and a sky illumination reference consisting of an opal glass diffusing plate mounted in the top of the aircraft. Through electronic control of the lamp and graybodies, and by attenuating optical filters for the sky illumination, the radiation from all but the ambient temperature reference sources is under operator control. During data collection, all internal sources are monitored and recorded manually by the operator. To assure their validity as references, these sources are calibrated periodically against external standards in the laboratory.

The scanner views the terrain during 90° of its scan, providing an external field of view (FOV) $\pm 45^{\circ}$ from nadir. A nominal 0.1°C NEΔT and a 1% NE$\Delta\rho$ are achieved.* The system operates at a constant scan speed of 60 scans per second. Electronic bandwidth was tape-recorder limited to a range of DC to 80 kHz. The amplitude and frequency response is linear within 3 db over this bandwidth. The scan angle response of the system is within 4% of the nadir value throughout the scan FOV. The instantaneous FOV of each spectral band is 2.0 to 3.0 mr, depending on the particular radiation detector or limiting aperture size. The imagery is roll-stabilized and the scan plane can be adjusted for oblique viewing from the normal vertical to any position up to 52° forward of nadir. The radiometric temperature accuracy of the thermal infrared bands is approximately 1°C at the scanner aperture.

All detector assemblies in the M7 system are aimed along a common line-of-sight. Thus all spectral bands are in registration except those from a special detector assembly which has

*NEΔT = Noise Equivalent change in Temperature.
*NE$\Delta\rho$ = Noise Equivalent change in reflection.

elements positioned side by side along the scan track at nadir. Only one of the elements of this detector assembly is in exact registration with other scanner spectral bands . (See Ref. [44] for a more complete description of the M7 scanner and its performance.)

4.2 M5 MULTISPECTRAL SCANNER

The same or similar four detector assemblies used in the M7 scanner were previously used in a different configuration in the M5 multispectral scanner system. The significant difference in the two systems was that in the M5 system each detector assembly had a separate line-of-sight. Therefore, only those spectral bands within a single detector assembly were in registration. In the M7 system, all detector assemblies had a common line-of-sight. For machine processing of the data, it is necessary that all spectral bands be in registration when collected or bear some programmable relationship to each other so that they may be brought into registration during processing.

In 1965 when the M5 system was developed, it was configured around readily available airborne scanners originally developed for military reconnaissance. The twenty multispectral data channels (see Table 12) were obtained by using four detector assemblies, one installed in each end of two dual-ended scanners (See Figure 34). A choice of detector configurations was available, but the basic grouping for data collection was:

(1) Scanner 1
  End A: GeHg detector filtered for 8.0 to 13.5 μm
  End B: InSb detector with 3 elements filtered for 1.0 to 1.4 μm, 2.0 to 2.6 μm and 4.5 to 5.5 μm

(2) Scanner 2
  End A: Spectrometer with 12 photomultiplier detectors over a range of 0.4 to 1.0 μm
  End B: InAs detector with 3 elements filtered for 1.0 to 1.4 μm, 1.5 to 1.8 μm and 2.0 to 2.6 μm

As assortment of detector/filter conbinations was available for substitution in End B of each scanner. These include a photomultiplier filtered for 0.33 to 0.38 μm, single element InAs or InSb detectors with filters for any of the wavelength bands shown for the 3-element detectors, a single element HgCdTe detector with a selected wavelength band between 1.0 and 12.5 μm and a dual element HgCdTe detector with two wavelength bands between 8.2 and 12.1 μm.

The scanners were modified to provide a single scanning mirror surface for each detector assembly at a fixed scan rate of approximately sixty scans per second. The single scanning surface was selected (by covering one of the two scan mirror surfaces) in order to restrict the detector to a single radiation input at any one time. The scan rate selected was the maximum available for the particular scanner and was fixed to simplify scanner controls. Most of

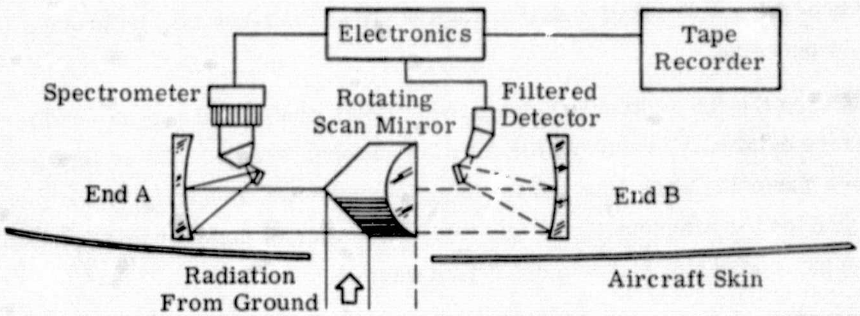

FIGURE 34. SIMPLIFIED SCHEMATIC OF AN M5 SCANNER

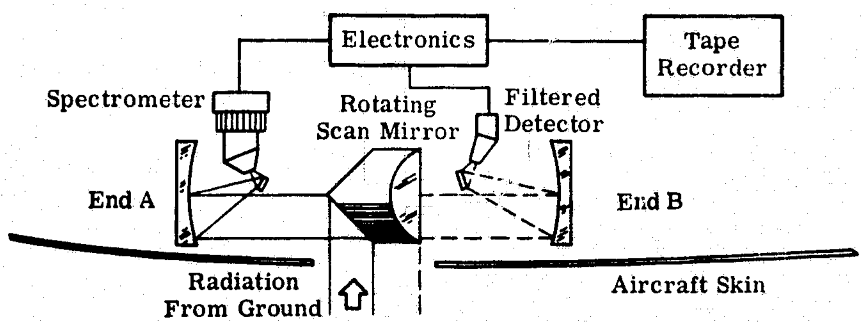

FIGURE 34. SIMPLIFIED SCHEMATIC OF AN M5 SCANNER

the data were collected at low altitudes. This required the maximum scan rates, and the scan overlap at higher altitudes was acceptable. With this scan rate and a normal aircraft ground speed of 120 knots, a continuous registration of terrain without scan overlap was obtained at an altitude of about 1,000 ft.

For calibration of the radiation input to each detector channel, scanner 1 contained two thermal reference plates and a lamp radiation source, and scanner 2 contained two lamp sources and a solar reference source; these were registered in the detector outputs during each line scan. The thermal plates provided two graybodies as temperature references for the thermal-IR channels (4.5 to 5.5 μm and 8 to 13.5 μm), and the lamps provided radiation reference levels corresponding to the reflected energy (from solar illumination) of typical targets in the data channels from 0.3 to 2.6 μm. The dark interior of the scanner was registered as the zero-radiation input for the scanner channels in the 0.33 to 2.6 μm region.

The electrical outputs of the radiation detectors were amplified for standard FM recording on magnetic tape recorders with an electrical bandwidth of from near DC to at least 20 kHz. With appropriate selection of amplifier gains, DC restoration, and special electronic filtering in the tape playback, a bandwidth of DC to 40 kHz was achieved in some data. The maximum information bandwidth of the scanner itself was approximately DC to 70 kHz. The separate detector outputs were displayed on oscilloscopes to the airborne operators, who selected the appropriate amplifier gains to match each signal level to the dynamic range of the tape recorder. A separate tape machine recorded the output of each scanner.

System performance was adequate for registration of terrain in all scanner data channels during daylight hours under all weather conditions suitable for visual flight rules (VFR) aircraft operation; however, no clouds could be between the aircraft and the terrain. Only the thermal channels (4.5 to 5.5 μm and 8 to 13.5 μm) were operable at night or twilight. Data was collected at flight altitudes from 500 ft above terrain to 15,000 ft above sea level. However, at 500 ft scans did not cover all the ground under the aircraft because of the limited maximum scan rate and the minimum airspeed of the aircraft. The best scan overlap (approximately 50%) occurred at a flight altitude of 2000 ft above terrain and at a ground speed of 120 knots. The fixed scan rate produces increasing scan overlap at higher altitudes.

The nominal unobscured FOV of the scanners was 80° across the flight line and continuous in the flight direction. However, when the thermal reference plates were used with scanner 1, the unobscured external FOV was reduced to 37°. The lamp reference sources for scanner 2 were registered during the period of internal scan so that the external FOV for this scanner was unaffected by the calibration sources. The scan synchronization signal was stabilized about the roll axis to reduce significant pattern distortion in the imagery representing scanned terrain. No corrections were made for aircraft pitch and yaw during the scan.

The M5 system provided a maximum spatial resolution, or instantaneous FOV, of approximately 4 mr, limited by the tape recording bandwidth. The quantitative measure of the signal level (radiance) in each band was established by interpolation between two known radiation inputs at the scanner aperture. The radiation inputs were common to data channels within a scanner and could be compared between scanners. The radiation measurement accuracy of the M5 system was approximately the same as that for the M7 system. For a more complete description of the M5 system and its performance, see Reference [45].

4.3 M1A1 THERMAL SCANNER

The M1A1 airborne infrared scanner system was designed and constructed by ERIM as a geophysical research tool for the Terrestrial Sciences Laboratory of Air Force Cambridge Research Laboratories (AFCRL). The system consisted of the line-scanning unit and the image-recording unit. The line-scanning unit was derived from an AN/AAR-9, XA-2, furnished by AFCRL. This scanner underwent extensive modifications in video and synchronization electronics, optical configuration, and detector assembly in order to improve sensitivity and resolution. Significant improvement was achieved in scanner performance.

The line-scanning unit (Figure 35) consisted of (1) a four sided mirror, (2) a friction drive system to rotate the scanning mirror, (3) a Newtonian collecting optics system, (4) a liquid-nitrogen-cooled indium antimonide solid-state detector sensitive to radiation in the 1.0 to 5.5 μm wavelength region, (5) a solid state video preamplifier, and (6) synchronization generating circuits and a vertical gyroscope stabilizing network. All these were mounted on a rigid frame constructed of tubular stainless steel and anodized aluminum plate.

The infrared scanning system first delivered in 1965 was only capable of making an in-flight direct recording of the scanner video signal on moving photographic film. It required great skill, much experience, and some luck to record good imagery on a crucial flight mission. In 1967, the M1A1 underwent its first renovation; the single most important addition was the installation of a tape recording system. With this addition, the mission success or failure no longer depended upon the proper operation of the image-recording unit. However, the low frequency output (which is of prime importance to earth resource investigators) of the scanner was not recorded, in order to simplify operation.

A second renovation of the M1A1 scanner system commenced in the latter part of 1969 and was completed in the early summer of 1970. The major changes made to the equipment were: (1) elimination of an alternate two of the four scanning mirror surfaces so that the detector registered an internal view of the scanner between external line scans and only one mirror surface at a time provided a radiation input to the detector; (2) provision of low frequency coupling and DC restoration of the video signal (with reference to the constant radiation from the internal

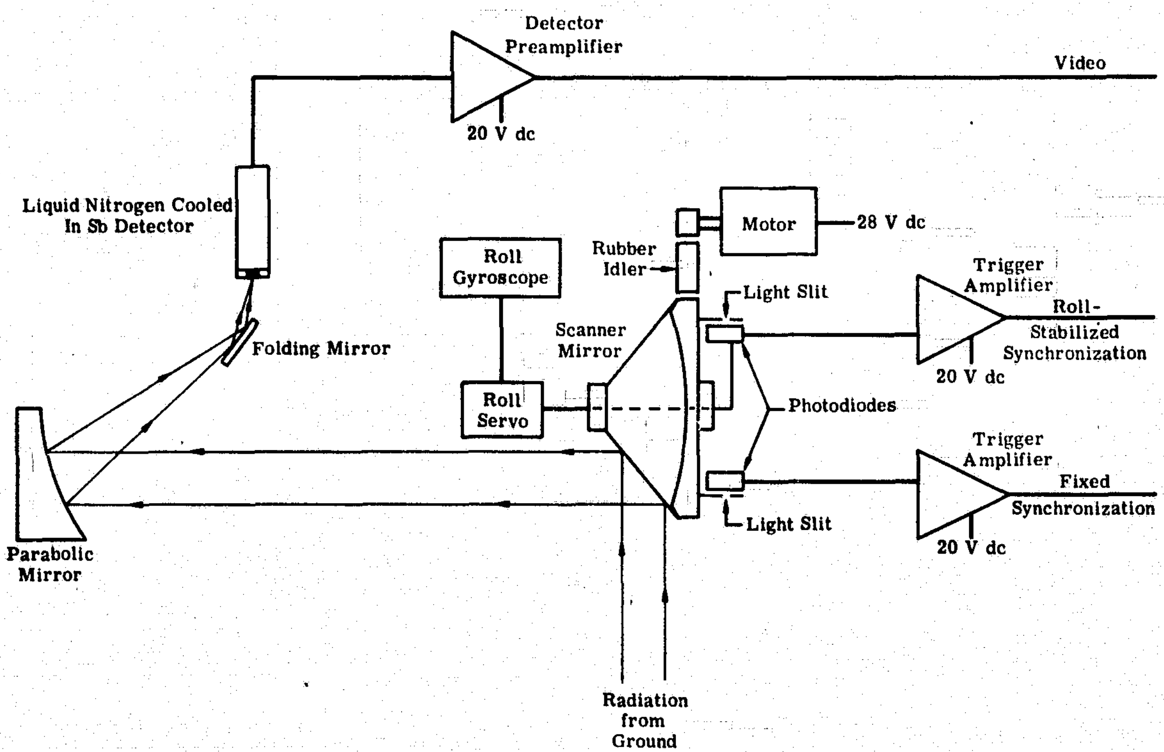

FIGURE 35. SCANNER UNIT

scanner view) by electronic circuit modifications and additions to the video postamplifiers; and (3) improvement of the sweep linearity and resolution of the airborne CRT film strip printer, through installation of a different type of cathode ray tube, a new high-voltage power supply, and beam deflection circuitry.

The renovated system demonstrated an overall performance of somewhat better than 3.0 mr spatial resolution and approximately 1.0°C temperature resolution. The DC signal variation during a scan did not exceed approximately 5% of the total signal amplitude. The scanner optical response, measured to determine responsivity as a function of scan angle, was constant in the field of view (FOV) within 14%. The scanner had a total FOV of 72°.

The major shortcoming of this thermal mapping system was that the imagery merely showed contrast between adjacent objects. No thermal references were used to provide a quantitative measure of radiation temperature or contrast, and until late 1970 the same radiation temperatures could not be related from scene to scene.

4.4 SLAR X-L RADAR

The Side Looking Airborne Radar (SLAR) is a synthetic-aperture, radar mapping device which scans the terrain parallel to the aircraft's ground track. The SLAR provides high-resolution ground mapping by utilizing pulse compression for range resolution (across track) and a long, synthetically obtained aperture for azimuth resolution (along track). Compared to visual photography, the resolution is generally poor because of the long wavelength, but radar systems can operate through clouds and vegetation cover to supplement the data derived from other sensors. Radar also provides large swath widths from low altitudes and non-visual information about the mapped surface.

As the aircraft flies over the selected terrain, a pulse generator circuit produces a continuous train of pulses used to drive the transmitter. The antenna radiates the energy toward the terrain below in a narrow beam. The energy strikes an area on the ground and the antenna collects the energy reflected back to the aircraft. The greater the distance from the aircraft to any portion of the imaged terrain, the greater the time delay in the return of the reflected signal. By accurately measuring the time delay, SLAR differentiates the echoes that return to it.

The backscattered energy is converted into voltage variations which in turn modulate the intensity of CRT (cathode ray tube) displays. The recording film is transported across the face of the CRT's at a rate proportional to the aircraft's ground speed. The CRT's expose the film in "sweeps" or lines in synchronism with the radio frequency (RF) energy wavefront "sweep" over the terrain. The inflight recording of radar data is in holographic form which must be optically processed to produce imagery.

The original ERIM radar system operated at only X-band frequency with only one return signal recorded. In September 1969, a provision was made for simultaneously recording both parallel and orthogonal polarization of the return signal. In may 1971, provisions were made for operating the system at either X- or L-band frequencies. Dual polarized returns were recorded for either frequency. In March 1973, the capability to operate simultaneously at X- and L-band frequencies was achieved. Two polarizations were recorded for each frequency. The resulting four data channels can be machine processed using multispectral processing techniques developed for the optical scanners.

The major limitation in SLAR data for earth resource applications is that the data lack references which could make them quantitative or at least repeatable. The radar imagery merely displays contrasts in a scene.

The characteristics of the ERIM multiband SLAR system are summarized in Table 13.

4.5 BORESIGHT CAMERAS FOR AIRBORNE SYSTEMS

The boresight aerial cameras used by ERIM in conjunction with MSS and SLAR airborne mapping systems were the military type K17, KB8, P220 and P2. The K17 uses 9.5-inch film, the other cameras 70mm film. The cameras were designed for daylight photographic reconnaissance. The K17 is a simple, relatively reliable camera with limited performance. The other cameras are complicated and unreliable, with performance exceeding the boresight requirements. The basic requirement for the boresight cameras was to record the visual view of the instruments under development to aid in the manual interpretation of the scene imagery. These cameras tended to function as remote ground observation devices.

The performance characteristics of these cameras are listed in Table 14. All cameras were mounted directly on the airframe; inflight leveling or alignment was through manual adjustments. No stabilization, image motion compensation, or automatic exposure control was available for any of the cameras. The camera operator had inflight access to the cameras for magazine changes and exposure adjustments.

None of the cameras had a color-corrected lens; nonetheless, all produced apparently acceptable color fidelity. The use of color film in the K17 was not recommended because of the slow lens; however, under bright illumination conditions, acceptable color work was produced with this camera.

A variety of film and filters were available for these cameras. The following film-filter combinations were most often used:

TABLE 13. CHARACTERISTICS OF X- AND L-BAND SLAR

C46 Flying Laboratory

X-band side-looking imaging radar - dual channel, parallel and orthogonal polarization

L-band side-looking imaging radar - dual channel, parallel and orthogonal polarization

Simultaneous operation of X- and L-band radar is normal operating mode

X-Band Radar

9.3 GHz center frequency

Resolution variable from classified levels to unclassified by DOD declassification directive (30' × 30')

Range < 10 nautical miles

Swath width 3nm variable from 1 to 10 nautical miles with modifications

Depression angle variable from near zero to 60^{o} with modifications

L-Band Radar

1.165 GHz center frequency

Resolution variable from classified levels to unclassified by DOD declassification directive (30' × 30')

Range < 5 nautical miles

Swath width 3 nm variable from 1 to 10 nautical miles with modifications

Depression angle variable from near zero to 60^{o} with modifications

Camera

70mm P-2 with 3" or 6" focal length lens

45^{o} center depression angle

Navigation

Litton - LTN-51 Inertial Navigation System

Data Processing

Optical data processing system - strip map output imagery and/or prints

Image digitizing system - imagery in digital form; nine channel digital tape - 8 bit quantization linear or log output

Data Analysis

Statistical recognition

Deterministic algorithm

TABLE 14. PERFORMANCE CHARACTERISTICS OF AERIAL CAMERAS

	K17D*	KB8A*/P220	P2*
Magazine type	A5A	LA97A	LA97A
Film capacity	9.5 in. × 200 ft	70mm × 50 ft	70mm × 50 ft
No. of exposures	250	230	230
Max. cycling rate	1/3 cycle/sec	5 cycles/sec	5 cycles/sec
Shutter speeds	1/50-1/400 sec	1/500-1/2000 sec	1/500-1/2000 sec
Max. AWAR†	25 lines/mm	42 lines/mm	30 lines/mm
Focal length	6 in.	38 mm	3 in.
Max. aperture	f/6.3	f/4.5	f/2.8
Angle of view	73°44'	73°44'	41°06'

*Military type

†Area-Weighted Average Resolution

Kodak Film Type		Filter
Panchromatic	2403	W12, W15, 25A
Infrared B&W	2424	25A, 87C, 89B
Color	SO397	1A, 2B
Infrared Color	2443	W12, W15

Most of the filters were glass-mounted. The viewport in the aircraft was covered with plexiglass, the optical transmission of which was uniform for film-sensitive wavelengths.

The ERIM photo laboratory processed all black-and-white film; color film was sent to the Mead Corporation in Dayton, Ohio for processing.

5
DATA RETRIEVAL

Potential users of ERIM's remote sensing data who are not familiar with the formats available will find it helpful to first review the various functions involved in airborne sensor data recording and reproduction.* The remainder of this section will be devoted to describing the inflight data recording systems, postflight imagery reproduction on film, and postflight data reproduction on magnetic tape. Also, a procedure for obtaining ERIM data is described.

5.1 INFLIGHT DATA RECORDING

All of the remote sensing data collected by ERIM's airborne sensors over the past nine years have been recorded during flight on magnetic tape for the optical scanners or film for the imaging radar and cameras. The recording and playback equipment employed with the various scanners have progressed over the years from relatively simple tape machines with limited capabilities to more sophisticated equipment providing a wider electronic bandwidth. The basic analog format of the scanner recording systems remained unchanged, however, making retrieval and analysis of the data from past years relatively straightforward using common equipment.

Each of the three basic sensors (MSS, SLAR and cameras) used by ERIM's flight facility to collect remote sensing data has its own unique method for recording the data from the ground. Two of the sensors, MSS and SLAR, are scanning devices, i.e., they receive signals continuously while the sensor IFOV moves over the flight path scanning the terrain. Hence, the recording system for these sensors must be capable of recording long uninterrupted streams of data in multiple bands. Magnetic tape is used on the MSS system partially to preserve the signal in electrical format for machine processing and partially to record the great dynamic range of signals. The SLAR system, on the other hand, uses roll photographic film to record the signals received in holographic form, which preserves the wide dynamic range. The data rate of the SLAR system is so large that magnetic tape could not be used. The important thing to note is that neither of these systems provides visual imagery on film as its raw output. Both MSS and SLAR require some form of postflight processing or data reproduction before an image of the terrain is obtained.

The aerial camera, on the other hand, does provide usable images of the ground on film as raw data. In most instances, the photos are used as flight line verification for the other sensors. A brief description of each of these recording systems follows.

*User representatives will also find it constructive to discuss possible processing work with ERIM data processing and analysis personnel who, from wide experience, can offer many helpful suggestions.

5.1.1 ANALOG MAGNETIC TAPE FOR SCANNERS

All of the multispectral (MS) data collected by ERIM's scanners since 1966 has been recorded on 10-inch analog tape reels. Prior to the summer of 1971, two tape recorders were employed simultaneously, each usually recording different spectral bands. Combinations of two one-inch, fourteen-track machines, or one one-inch and one half-inch, seven-track machine, were used at various times depending on the availability of tape recorders. More than one machine was necessary because the M5 system had more spectral channels available for recording than could be accommodated on a single one-inch, fourteen-track machine.

After July 1971, when the double scanner M5 system was replaced with the single M7 scanner, only a lone fourteen-track tape machine was employed. The basic operation of the recorders remained the same, however.

All MS data have been recorded at 60 inches per second (IPS) which, for a ten-inch tape reel and an aircraft speed of 120 knots, provides up to 28 statute miles of uninterruped data. Usually, the data line lengths vary greatly over a single mission and several lines may be recorded on a single tape. Of course, for the two recorder setup, two tapes would exist for the same lines. If the total mission involved more than 28 statute miles of data, then several tapes might be required. The flight logs generated for each mission provide documentation of these reels and flight lines.

The tape recorders, when operated in the standard FM mode, have an electrical bandwidth of DC to 20 or 40 kHz depending on the FM center frequency. With appropriate selection of amplifier gains and special electronic filtering in the tape playback, a bandwidth of DC to 40 or 80 kHz was achieved. The FM electronics were set for ±30% deviation about the center frequency (either 108 kHz or 216 kHz) to record an input signal of 0 to 3 volts. In record mode, the tape machine electronics were set up to operate in an abnormal manner. For zero signal input, the carrier frequency was set at the high frequency (+30% deviation) instead of at the normal center frequency. For <u>positive</u> signal input (no negative signals present), the carrier frequency was shifted downward to a -30% deviation from the center frequency. Zero volts represents dark or cold targets.

The separate detector outputs were displayed on oscilloscopes to the airborne operators, who selected the appropriate amplifier gain to match each signal level to the dynamic range of the tape recorder. All video signals were recorded FM while the synchronization signal was recorded either direct or FM, depending on the year in which the data was obtained. The carrier frequency of the FM signal was either 108 kHz or 216 kHz, again depending on when the data was obtained. However, since 1971 all synchronization and video signals have been recorded FM at 216 kHz. While there has been no permanent assignment of a particular scanner spectral band to a particular tape channel, the usual practice has been to record the scan-synchronizing reference and line count on tape track 7. Since the tape machine has staggered heads, the six spectral bands most likely to be machine processed were assigned to odd tracks along with the sync in order to minimize misregistration of the multispectral data because of tape transport characteristics (skew, stretch, etc.). When optimized registration of the imagery in all tape channels is desired, analog delay lines are used in tape duplication on the processing tape machine to bring common objects in the imagery into exact registration.

It should be noted here that time-registered data is limited to that data recorded on a single tape machine. Hence, any processing requiring multispectral coverage of a common area on the ground must be done with those signals recorded on a single tape.

5.1.2 FILM FOR RADAR

The ERIM dual frequency radar does not produce visible radar imagery in flight. Instead, radar data are recorded in the aircraft on film in a holographic format for subsequent processing on the ground to produce visual radar images of the scanned terrain. Each of the four available channels utilizes different radar echo signals. One channel produces an image from the X-band parallel polarized signals, a second uses the X-band cross-polarized signals, a third uses the L-band parallel signals, and a fourth uses the L-band cross-polarized signals.

The four channels of stored radar data are recorded on parallel strips of photographic film, with X-band data on one 70mm film strip and L-band on another. The various radar signals are synchronously detected in order to preserve both phase and amplitude information, and are routed through the CRT displays and onto their accompanying cameras where the films are exposed. These films are on 100-ft reels which have the capacity to record for about 450 kilometers of flight line length per reel. The reels can be changed in the air.

5.1.3 FILM FOR BORESIGHT CAMERAS

The aerial cameras used with the MSS and SLAR systems provide the higher spatial resolution required for shape identification of some terrain features and conditions. Areal camera coverage was secondary to the MSS and SLAR coverage. The ERIM cameras provided adequate boresight data for visual analysis of the site.

The boresight cameras were operated during daylight with whatever film/filter combinations were requested by the PI. Often lighting conditions were unsuitable for good photography but the cameras were operated anyway to record the visual view of the MSS and SLAR. This boresight photography was developed by ERIM and supplied to the PI without screening or evaluation.

5.2 POSTFLIGHT IMAGERY REPRODUCTION ON FILM

The purpose of this section is to describe the functions required to convert the SLAR and MSS inflight data recordings into film imagery.

5.2.1 MS SCANNER IMAGERY

Although the original recording of all MS scanner data is on analog magnetic tape in the aircraft, the data users usually require that at least some of the spectral bands be printed on film for visual analysis. This is accomplished in the laboratory after a flight and is one of the most basic forms of reproduction. Primary uses of this scanner film data are to document flight line coverage and for manual editing of the imagery to select specific areas to be machine processed. Indexing of the selected areas for processing is accomplished either by reference to the scan line count in the sync signal or to a visual display of the imagery.

The filmstrips of scanner imagery are reproduced at real-time rates, one track at a time, from the original analog magnetic tapes. The laboratory tape machine has associated electronics which provide operator selection of playback electronic bandwidths of from 10 kHz to 100 kHz. The reproduction bandwidth is selected to match the optimal information bandwidth of the various-size detectors used in the scanner. For instance, the large spatial resolution of the layered thermal detectors shows the best signal-to-noise at the lower bandwidth limit, and the small spatial resolution of the spectrometer in the visible region requires the upper bandwidth limit. Other electronics in the filmstrip reproduction facility provide clamping of the dc level of the signal to radiation references for dc restoration, and the registration of radiation reference quantities through sample gates. These reference quantities can be stored temporarily and, if desired, retrieved for reformatting of the data in analog form. A data "slate" for film labeling through direct exposure is also available.

The filmstrip of scanner data is made by photographing an intensity-modulated line scan on the face of a cathode ray tube (CRT). The intensity modulation is a direct function of voltage variation in the particular radiation detector output recorded on magnetic tape. Normally the 0- to 3-volt variation of the tape signal is transferred to the film as the total variation in gray scale. However, this transfer relationship is controlled by the operator. Other relationships may be selected, such as remaining in the linear portion of film sensitivity. Between runs, an equal-voltage-increment gray scale is printed on the film to establish the voltage-to-film tone calibration.

The filmstrip camera drives 70mm film across the CRT face, perpendicular to the line scan, at rates proportional to the aircraft ground speed and absolute altitude. The camera film speed range includes absolute flight altitudes of from 1000 to 10,000 ft at a ground speed of 120 knots to provide an imagery scaling on film of the absolute flight altitude per inch of film. At the higher altitudes, several line scans are integrated in the film display because of overlap at the constant scan rate. At the lower altitudes, the imagery may not be contiguous (no overlap) for the small detector spatial resolution.

Filmstrip displays of scanner imagery are not restricted to the mere printing of a particular tape channel on film. The electrical signals from the separate tape channels can be combined or processed in various ways before printing. The methods often used are level slicing and the mixing of spectral bands to simulate other instruments. An example of the latter is the simulation of ERTS-A spectral bands by controlled mixing of selected M7 scanner bands. The spectral response of each channel of the ERTS scanner can be simulated by a weighted addition of appropriate M7 scanner channels.

For the majority of ERIM multispectral missions, four spectral bands have been reproduced as filmstrip imagery. The filmstrip negative and one print are sent to the Principal Investigator (PI) directly or, in the case of NASA missions, to NASA where duplicate prints and negatives are made for transmittal to the PI. At least one print copy of all filmstrip imagery delivered to PI's is retained at ERIM in an imagery vault. No imagery negatives are stored in the vault at ERIM except for those missions flown for ERIM PI's.

5.2.2 RADAR IMAGERY

SLAR radar imagery, stored on film at ERIM, is, in general, viewable imagery. The original data film, which is also available, requires further processing before an image of the ground is obtained. This imagery is produced by inserting one channel of recorded data into an optical processor where two dimensional pulse compression is performed. A visible image is displayed at the output plane of the optical data processor.

This output imagery can be observed in the processor, but it is at small scale. Close examination of the imagery is facilitated by use of a microscope. The processor output image is in the form of a real optical image with an extremely large dynamic range of intensity corresponding to the large reflectivity variation of objects illuminated by radar wavelengths. Some image components may be 40 or 50 db brighter than the background level of the image. These bright spots are prominently visible to an observer, and are usually found to be due to specular reflection from man-made objects.

Four separate output films can be made of each channel's imagery. These have the same small scale as the imagery in the processor. They can be examined on a light table with the aid of a microscope, or they can be projected for observation at larger scale. The output films cannot adequately display the large dynamic range of the radar image formed in the optical processor because of the limited dynamic range of the photographic emulsion; these films are usually exposed and developed to present small amplitude signals visibly. These small signals are the image components that comprise most of the terrain image, and are referred to as "ground painting" signals. The brighter components of the radar image are then greatly over exposed and appear with photographic blooming of their main lobes, visible side lobes, often with some modulation side bands, and occasionally with photographic haloes. These effects can be helpful in detecting the highly reflecting objects if they are properly interpreted. Of course, the bloomed images infringe upon their neighbors and may obscure some dimmer image components.

5.2.3 BORESIGHT CAMERA IMAGERY

Black-and-white film obtained with ERIM's aerial cameras is developed at ERIM while the color film is sent to a commercial developing laboratory. ERIM retains, in the imagery vault, one filmstrip print of all black-and-white photography. The black-and-white negative and a print are sent to the PI either directly or through NASA who provides duplicates to the PI. The color photography obtained is always in the form of positive transparencies. No prints are made and the PI is sent the original (or a NASA duplicate as the case may be). Only for those missions flown for ERIM PI's will aerial photography transparencies be available from ERIM's vault.

5.3 POST-FLIGHT DATA REPRODUCTION ON MAGNETIC TAPE

The use of multispectral data has produced a variety of analysis and recognition techniques. These techniques have included the use of digital computers in the analysis of targets and backgrounds as objects or distributions in multispectral space and for the development and testing of recognition techniques.

Frequently, users who have access to data processing facilities request either duplicate analog tapes of data or digitized data for their own analysis. Properties of these two data formats are discussed below.

5.3.1 DUPLICATE ANALOG TAPES

The duplicate analog tape is simply a copy of the original data tape. All channels are commonly transferred from the original to the duplicate. A special analog tape duplicating setup transcribes the FM signals to the second tape, normally without going through the demodulation and remodulation process.

The video and synchronizing data are recorded in IRIG* standard FM with ±30% deviation. The synchronizing signal consists of two pulses of opposite polarity and close proximity, the

*Inter-range instrumentation group.

first pulse being the non-roll-corrected sync, while the second is the roll-corrected sync. Since all tapes are supplied wound fully forward, they must be completely rewound before playing. Unless specifically noted, all channels on the duplicate correspond to the same channels on the original.

Faults existing in the original tapes can often be corrected or relieved in the duplicated tapes. Examples are polarity reversals in a particular track, or minor misregistration of the imagery between tracks. Because the correction of such faults usually requires demodulation and remodulation of the FM signals, some signal-to-noise is then sacrificed in the duplicating process. Duplicates, however, are not normally available off the shelf for any of ERIM's data. They are generated only when requested.

5.3.2 DIGITAL TAPES

Although digital processing of ERIM data has been used quite extensively in remote sensing applications, computer compatible tapes (CCT's) are generally not immediately available for the majority of the data stored at ERIM. Most new applications needing digital processing would require completely new A/D conversion. The facilities maintained by ERIM can supply digital data tapes, suitable for computer processing, in one of several formats. All data are digitized to 9 bit accuracy (8 bits plus sign). Flexible control of the A/D conversion process allows sampling of the data once every resolution element, once every other resolution element, and so on. Also, scan lines of data may be skipped. Unusual sampling formats may also be accommodated. Normal formats are as follows: sample each resolution element twice; sample each resolution element once; sample every other or every fourth resolution element. Any number of lines up to nine may be skipped.

Consultation with data-processing personnel at ERIM is recommended before specifying which format is to be used. This will assure format compatibility with a particular machine.

Areas to be digitized can be specified by marking data locations on a print of scanner imagery. Facilities will soon be available to put scan line numbering information on the film-strip so that a precise specification of areas to be digitized (in terms of starting and stopping line number) will be possible. Data normally digitized include calibration and dark level information, which will be supplied in bipolar form unless otherwise specified. A graymap printout of video data alone will also be supplied. Line and point numbers on the map correspond to line and point numbers on the tape.

For radar applications, a digital tape is generated by scanning and recording the film output image intensities on magnetic tape. Computer analysis of the four channel radar imagery is then possible, although signal-to-noise is limited by the dynamic range of the original film.

5.4 PROCEDURE FOR OBTAINING ERIM DATA

ERIM has maintained several data storage vaults through the years as MSS and SLAR data have accumulated. Since most of the data has been collected at government expense, it should be used whenever possible in helping to solve earth resource problems. Any United States citizen or agency who might make use of some of the remote sensing data stored at ERIM is encouraged to do so. In the remainder of this section, a procedure for obtaining both unprocessed and processed ERIM airborne data is discussed.

5.4.1 UNPROCESSED AIRBORNE SENSOR IMAGERY

Any potential user of ERIM airborne sensor data requiring either duplicate raw data or reformatted data onto tape or film should contact Mr. Philip Hasell (for MSS) or Mr. Richard Larson (for SLAR) at ERIM for details on formats and estimated costs of retrieval. Authorization for ERIM's release of copies of the unprocessed data must be obtained (by the user) from the agency who originally contracted for the data collection before any duplication or reformatting can actually proceed. The contracting agencies are given after each mission in the tables of Section 3. Further information on details such as site description, ground observation, purpose of the original data collection, and what has been done with the raw data must be obtained from the mission PI.

5.4.2 PROCESSED/ANALYZED AIRBORNE DATA

General information on the application of ERIM airborne sensor imagery to particular earth resources problems and its approximate cost can be obtained from Mr. Donald Lowe (MSS), Mr. Fred Thomson (MSS), or Dr. Philip Jackson (SLAR) at ERIM. Data processed or analyzed by ERIM is released in a report which acknowledges the original sponsor for the data collection as the source of the sensor data. Any release authorization necessary for the processing and/or analysis of airborne data would be obtained by ERIM.

Specific details on what can be done digitally in the areas of statistical analysis and object classification of MSS airborne data and their estimated cost is available from Dr. Jon Erickson or Mr. Richard Nalepka. Either Mr. Philip Hasell (MSS) or Mr. Richard Larson (SLAR) can help determine the costs of simple analog processing such as level slicing and ratioing of bands.

5.4.3 SUMMARY OF DATA REQUEST PROCEDURE

A. Unprocessed Airborne Sensor Imagery

1. Contact Philip Hasell (MSS) or Richard Larson (SLAR) at ERIM for more information on formats and costs.

2. Obtain release authorization from sponsoring agency of data collection.
3. Contact mission PI for details on site description, ground observation, etc.

B. Processed Airborne Sensor Imagery
   1. Contact Donald Lowe (MSS), Fred Thomson (MSS), or Philip Jackson (SLAR) at ERIM for more information on the applications of processing techniques to a given earth resources problem.
   2. Contact Jon Erickson or Richard Nalepka at ERIM for specific MSS digital processing techniques
   3. Contact Philip Hasell (MSS) or Richard Larson (SLAR) at ERIM for information on simple analog processing such as level slicing or ratioing of bands.

Appendix A

LIST OF PUBLISHED DOCUMENTS WHICH USE AIRBORNE SENSOR DATA COLLECTED BY ERIM

This appendix is a listing of published technical reports and papers which made use of the airborne sensor data collected by ERIM. It was originally intended that each data set reference documents using that particular data set, but this turned out to be an overwhelming task. When principal investigators responded to our queries regarding the use they had made of a particular data set, they responded by sending lists of references citing all documents using ERIM data. The additional effort and time required to identify a particular data set seemed unwarranted.

Therefore, the references are grouped by airborne sensor type and the major users of data from that sensor. Since most of the references to multispectral scanner data included machine processing of that data for analysis, and since ERIM and LARS (Purdue University) accomplished most of the processing of this type of data for investigators during the period covered, it follows that most of the published documents originate from these organizations even though the principal investigator may have been in some other organization.

The referenced documents are grouped as follows:

A.1 MULTISPECTRAL SCANNER DATA (M5 and M7 Systems)

- A.1.1 ERIM
- A.1.2 LARS
- A.1.3 Government Agencies
- A.1.4 Miscellaneous

A.2 THERMAL SCANNER DATA (M1A1 System)

A.3 SIDE LOOKING AIRBORNE RADAR DATA (X- and L-Band Systems)

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A.1 MULTISPECTRAL SCANNER DATA (M5 and M7 Systems)

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A.1 MULTISPECTRAL SCANNER DATA (M5 and M7 Systems) (Continued)

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A.1.1 ERIM (Continued)

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Appendix B

GEOGRAPHIC REFERENCE SYSTEM

The DMS geographic reference system, which indicates the general geographic zone in which data were collected, is similar to the World Geographic Reference System (GEOREF) described in Air Force Manual 51-40, Vol. I, Air Navigation, pages 3-34 through 3-38 and the NASA Earth Resources Research Data Facility World Geographic Reference system described in their Index, MSC-02576, July 1970, pages viii through xxvii.

The GEOREF is based on the normal geographic longitude and latitude projection lines of any specific chart, and defines a unit of geographic area in which a specific point lies. The GEOREF divides the earth's surface into 15° quadrangles of longitude and latitude with the point of origin at the 180th meridian and the South Pole (see Earth Zone Map, Figure B-1). The divisions extend eastward 360° from the 180th meridian, with each component zone of these divisions identified by a letter from A through Z, omitting I and O; and northward 180° from the South Pole with the zones lettered A through M, omitting I. This combination divides the earth's surface into 288 basic 15° quadrangles, each having two letters identifying the zone of longitude and latitude.

Each such 15° quadrangle (see GEOREF 15°- square sample quadrangle, Figure B-2) is further divided into 15 lettered 1° units eastward and 15 lettered 1° units northward. These 1° quadrangles are lettered from A through Q, omitting I and O. Quadrangles covering areas within the United States are shown in the United States Zone Map (Figure B-3).

The initial letter indicates the approximate longitude and the second letter indicates the approximate latitude. For example, the zone designated "GJ" indicates that the general geographic area for a given data type is located in the eastern half of the United States. If more than one zone is overflown, each zone is listed.

As an example, within a 1°-square quadrangle, the geographical location of Site 002 (Pisgah Crater, California), the coordinates of which are 116°16' to 116°34' W. longitude and 34°35' to 34°50' N. latitude is completely described by the four letters EJDE, and can be located as follows:

(1) On the Earth Zone Map, locate the 15° quadrangle "EJ" by reading right to "E" and up to "J."

(2) On the GEOREF 15° Square Sample Quadrangle, locate the 1° quadrangle "DE" with the sample "EJ" 15° quadrange by reading right to "D" and up to "E."

Site numbers have been arbitrarily assigned by NASA for areas which have been overflown and are indicated by a three-digit code. For the convenience of users, numbers covering test sites located within the United States are shown on a United States Test Site Map (Figure B-4). Where appropriate these test site numbers are attached to the four letter geographic reference code. For example, Pisgah Crater, California would be located as EJDE002. A list of site numbers, zone indicators, and test site titles follows the maps.

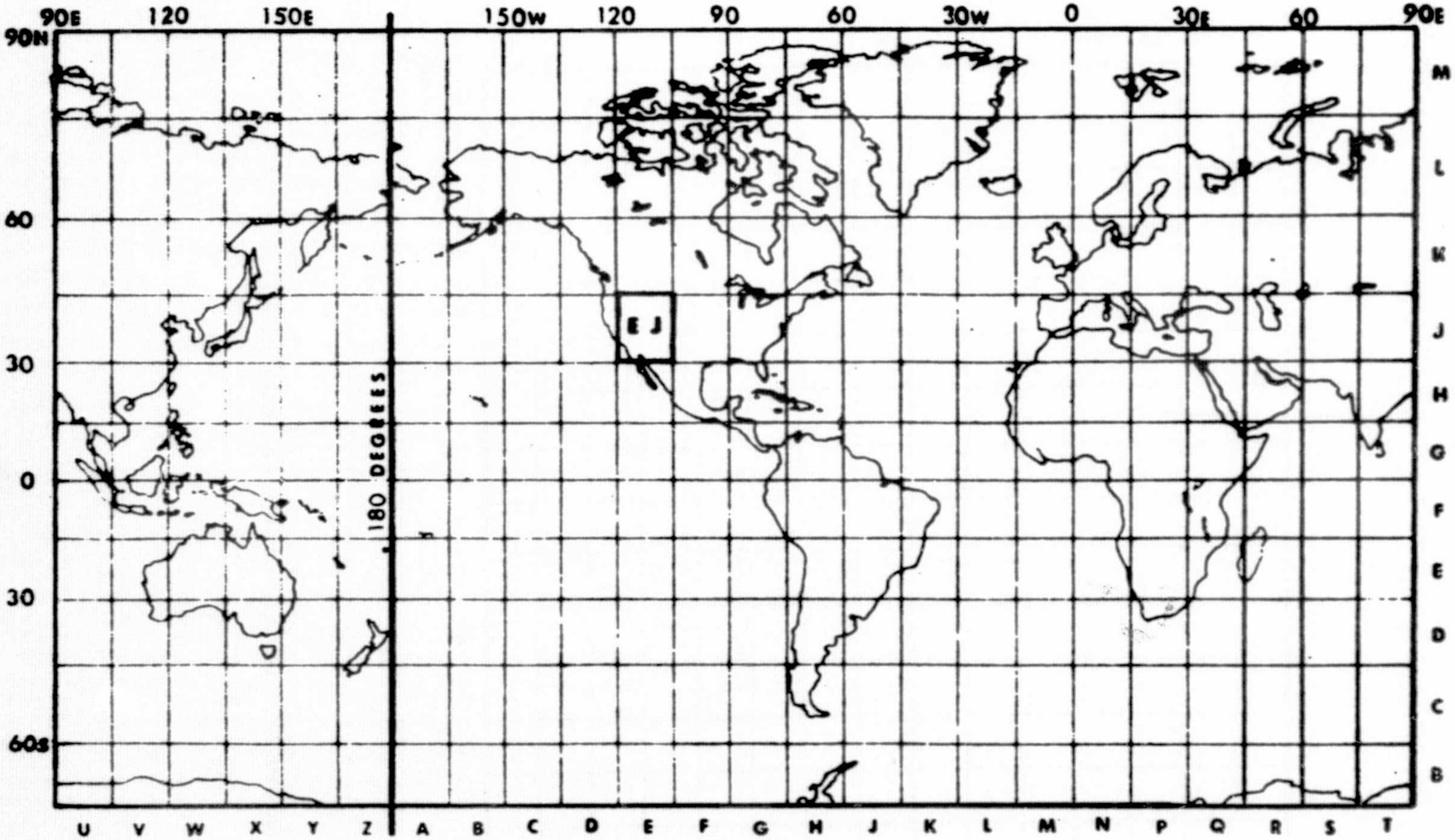

FIGURE B-1. EARTH ZONE MAP

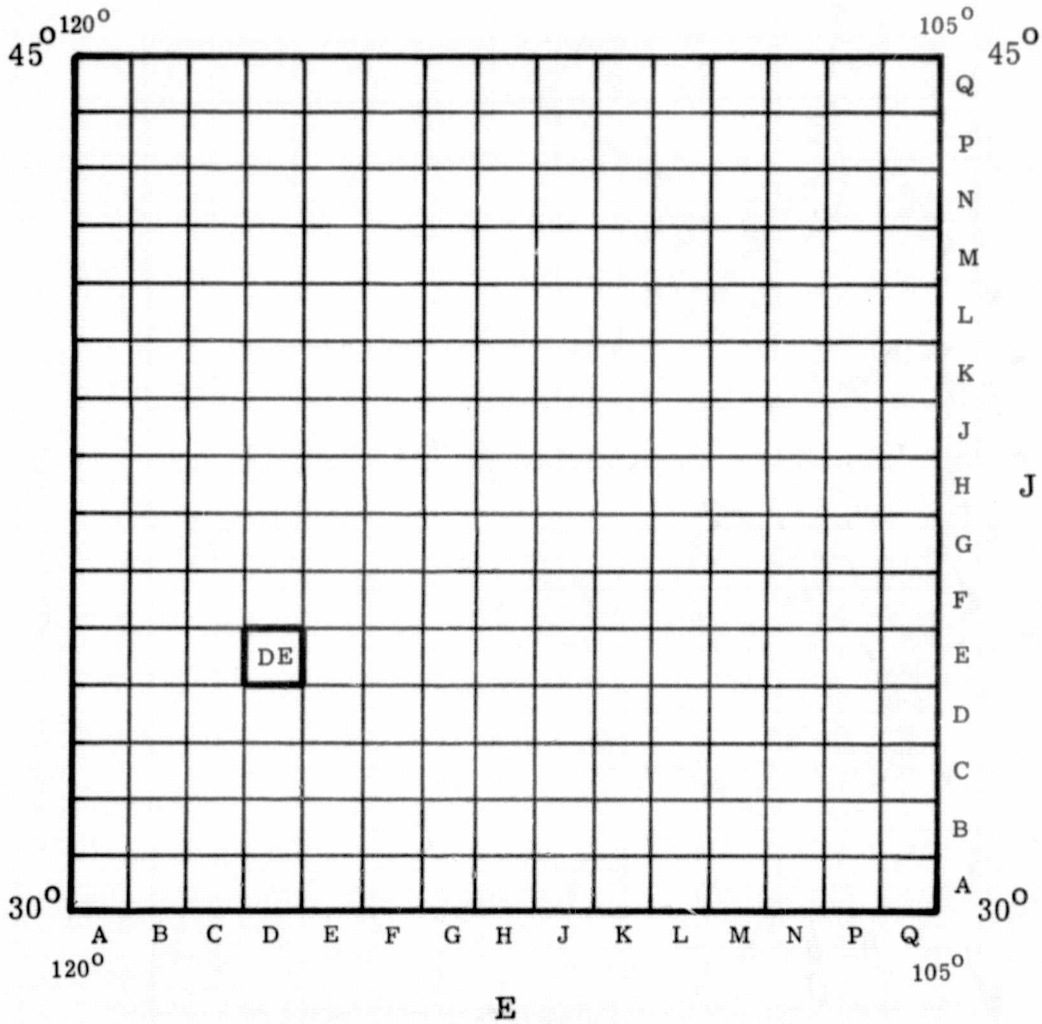

FIGURE B-2. GEOREF 15° SQUARE SAMPLE EJ QUADRANGLE

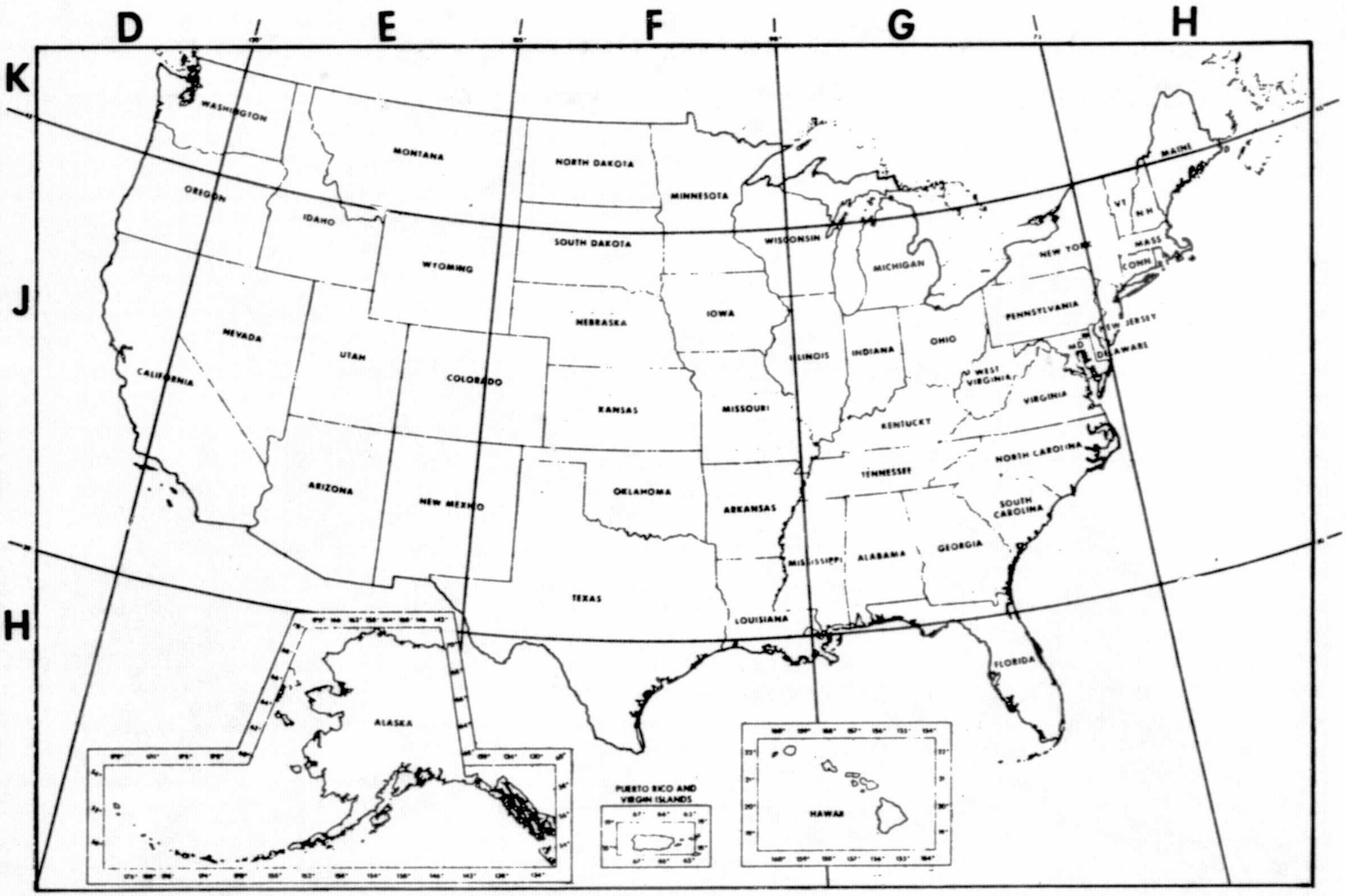

FIGURE B-3. U.S. ZONE MAP

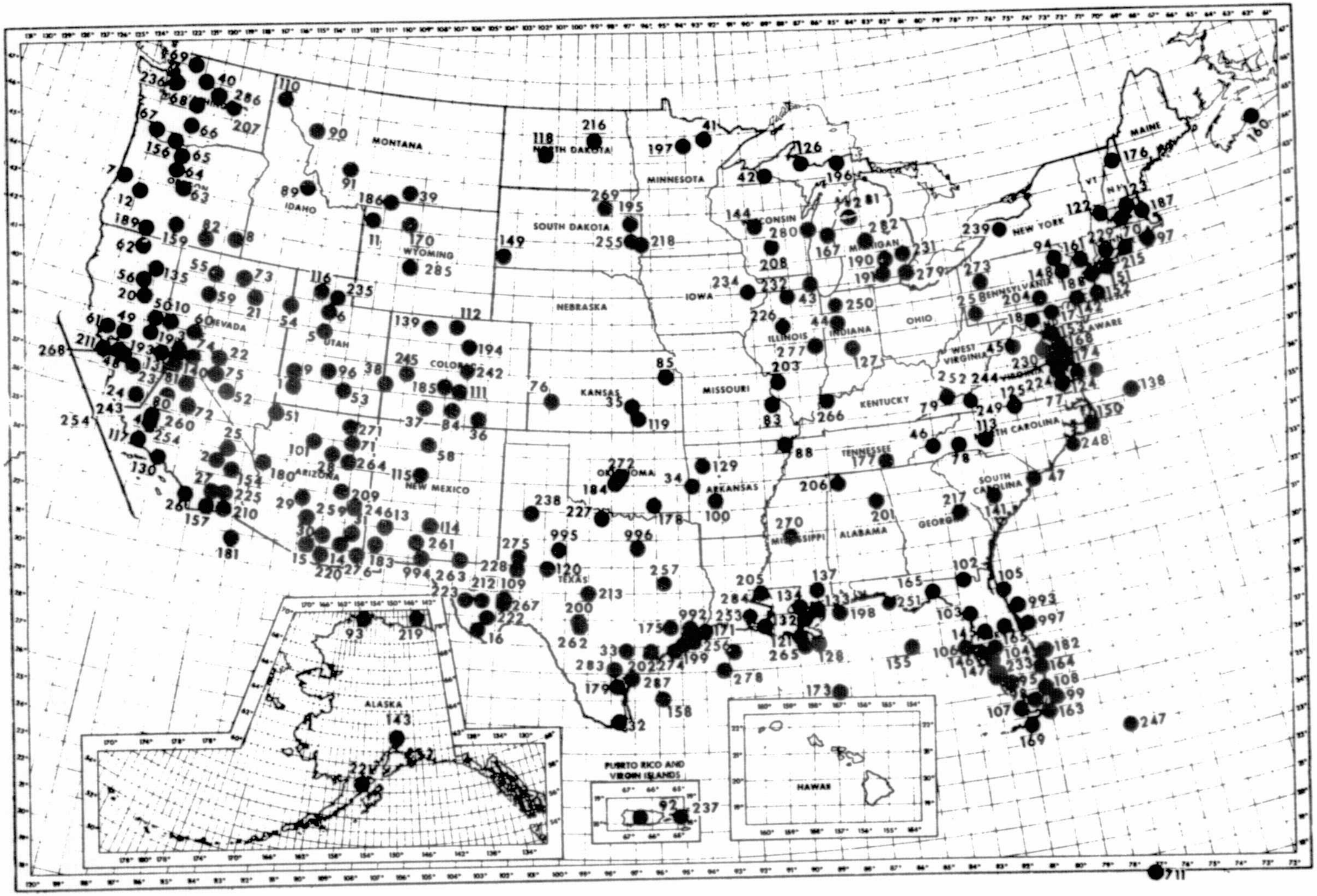

FIGURE B-4. USA TEST SITES

SITE	ZONE	TEST SITE NAME
001	EJ	CEDAR CITY (IRON SPRINGS), UTAH
002	EJ	PISGAH CRATER, CALIFORNIA
003	EJ	MONO CRATERS, CALIFORNIA
004	EJ	CARRIZO PLAIN, CALIFORNIA
005	EJ	EUREKA (TINTIC DISTRICT), UTAH
006	EJ	SALT LAKE (SALT LAKE DISTRICT), UTAH
007	DJ	COAST RANGE, OREGON/WASHINGTON
008	EJ	SOUTH OREGON STRIP, OREGON
009	EJ	SAN FRANCISCO DISTRICT, UTAH
010	EJ	CARSON CITY(COMSTOCK DISTRICT), NEVADA
011	EJ	YELLOWSTONE NATIONAL PARK, WYOMING/ MONTANA/IDAHO
012	DJ	CRATER LAKE, OREGON
013	EJ	SILVER CITY(CENTRAL DISTRICT), NEW MEXICO
014	EJ	LITTLE DRAGOON MOUNTAINS, ARIZONA
015	EJ	TWIN BUTTES (PIMA DISTRICT), ARIZONA
016	FH	SOLITARIO, TEXAS
017	GJ	BALTIMORE (HARFORD-YORK), MARYLAND/ PENNSYLVANIA
018	GJ	HAGERSTOWN (CENTRAL APPALACHIAN) PIEDMONT), MARYLAND/PENNSYLVANIA/VIRGINIA
019	EJ	SONORA PASS, CALIFORNIA
020	DJ	BUCKS LAKE, CALIFORNIA
021	EJ	BATTLE MOUNTAIN (RYE PATCH RESERVOIR/ RUBY MOUNTAINS), NEVADA
022	EJ	TONOPAH, NEVADA
023	DJ	INYO NATIONAL FOREST (WARD MOUNTAIN/ CRATER MOUNTAIN), CALIFORNIA
024	DJ	SAN ANDREAS FAULT, CALIFORNIA
025	EJ	DEVILS PLAYGROUND, CALIFORNIA
026	EJ	SCRIPPS BEACH, CALIFORNIA
027	EJ	SALTON SEA, CALIFORNIA
028	EJ	WINSLOW (METEOR CRATER), ARIZONA
029	EJ	PHOENIX, ARIZONA
030	EJ	TUCSON/AJO, ARIZONA
031	EJ	WILLCOX DRY LAKE, ARIZONA
032	FH	WESLACO, TEXAS
033	FH	GUADELUPE RIVER, TEXAS
034	FJ	OUACHITA MOUNTAINS, ARKANSAS/OKLAHOMA
035	FJ	WICHITA, KANSAS
036	FJ	SPANISH PEAKS, COLORADO
037	EJ	OURAY (SILVERTON/CREEDE DISTRICT AND SAN JUAN 20 QUADRANT), COLORADO
038	EJ	GREAT SAGE PLAIN (LISBON VALLEY), UTAH/ COLORADO
039	EK	EASTERN BEAR TOOTH MOUNTAINS, WYOMING/ MONTANA
040	DK	CASCADE MOUNTAINS (CASCADE GLACIER SITE), WASHINGTON
041	FK	MESABI RANGE, MINNESOTA
042	FK	OTTAWA NATIONAL FOREST (GOGEBIC RANGE), MICHIGAN
043	GJ	CHICAGO, ILLINOIS
044	GJ	PURDUE, INDIANA
045	GJ	ORANGE, VIRGINIA
046	GJ	ASHEVILLE, NORTH CAROLINA
047	GJ	MYRTLE BEACH, SOUTH CAROLINA
048	DJ	SAN PABLO RESERVOIR, CALIFORNIA
049	DJ	DAVIS, CALIFORNIA
050	DJ	DONNER PASS, CALIFORNIA
051	EJ	MESQUITE SEDIMENTARY, ARIZONA
052	EJ	NEVADA AEC
053	EJ	SPANISH PEAKS, COLORADO/CEDAR CITY, UTAH
054	EJ	SMOKE CREEK DESERT/HEBER, UTAH
055	EJ	HUMBOLDT BASIN, NEVADA
056	DJ	MT.LASSEN, CALIFORNIA
057	BH	HAWAII
058	EJ	VALLES CALDERA, NEW MEXICO
059	EJ	TOBIN RANGE, NEVADA
060	EJ	DIXIE VALLEY, NEVADA
061	DJ	THE GEYSERS, CALIFORNIA
062	DJ	MT. SHASTA, CALIFORNIA
063	DJ	NEWBERRY CRATERS, OREGON
064	DJ	CENTRAL CASCADE RANGE, OREGON
065	DK	MT. HOOD, OREGON
066	DK	MT. ADAMS, WASHINGTON
067	DK	MT. ST. HELENS, WASHINGTON
068	DK	MT. RAINIER, WASHINGTON
069	DK	MT. BAKER, WASHINGTON
070	HJ	HOPKINTON-MILFORD/TEMPLETON/ORANGE, MASSACHUSETTS
071	EJ	HOPI BUTTES, ARIZONA
072	EJ	COSO HOT SPRINGS, CALIFORNIA
073	EJ	LYNN DISTRICT, NEVADA
074	EJ	BENTON, CALIFORNIA
075	EJ	GOLDFIELD, NEVADA
076	FJ	GARDEN CITY, KANSAS
077	GJ	NORFOLK, VIRGINIA
078	GJ	CLEVELAND COUNTY, NORTH CAROLINA
079	GJ	MATEWAN, KENTUCKY
080	EJ	BIG PINE FAULT, CALIFORNIA
081	EJ	MT. MORRISON FAULT, CALIFORNIA
082	EJ	ALVORD VALLEY, OREGON
083	FJ	IRONTON, MISSOURI
084	EJ	ALAMOSA, COLORADO
085	FJ	LAWRENCE, KANSAS
086	HJ	ARGUS ISLE, BERMUDA
087	JK	GOOSE BAY, LABRADOR
088	FJ	MISSISSIPPI VALLEY, MISSOURI/TENNESSEE
089	EK	BLACKBIRD DISTRICT, IDAHO
090	EK	ALBERTON, MONTANA
091	EK	TOBACCO ROOT MOUNTAIN, MONTANA
092	HH	PUERTO RICO
093	BL	PT. BARROW, ALASKA
094	GJ	NORTHEAST PENNSYLVANIA (PEAT BOGS)
095	GH	EVERGLADES, FLORIDA
096	EJ	DIXIE/FISH LAKE NATIONAL FOREST, UTAH
097	HJ	CAPE COD/MARTHA'S VINEYARD, MASSACHUSETTS
098	GH	HOMESTEAD, FLORIDA
099	GH	FLORIDA STRAITS
100	FJ	HOT SPRINGS, ARKANSAS
101	EJ	SAN FRANCISCO VOLCANIC FIELDS, ARIZONA
102	GJ	STATENVILLE, GEORGIA/LAKE CITY, FLORIDA, PHOSPHATE
103	GH	CRYSTAL RIVER, FLORIDA
104	GH	WAUCHULA/TAMPA, FLORIDA
105	GH	CRESCENT BEACH SUBMARINE SPRING, FLORIDA
106	GH	CLEARWATER/NAPLES SUBMARINE SPRING, FLORIDA
107	GH	CAPE SABLE SUBMARINE SPRING, FLORIDA
108	GH	CUTLER AREA SUBMARINE SPRING, FLORIDA
109	FJ	SIERRA MADERA, TEXAS
110	EK	CLARK FORK, IDAHO
111	EJ	WET MOUNTAIN, COLORADO
112	EJ	NORTHEAST RANGE, COLORADO
113	GJ	FAYETTEVILLE, NORTH CAROLINA/NEWPORT, TENNESSEE
114	EJ	WHITE SANDS, NEW MEXICO
115	EJ	NEW MEXICO MINERAL AND STRUCTURAL BELTS
116	EJ	GREAT SALT LAKE, UTAH
117	EJ	LAKE CACHUMA, CALIFORNIA
118	FK	MISSOURI RIVER, NORTH DAKOTA
119	FJ	BUTLER COUNTY, KANSAS
120	FJ	LAKE COLORADO CITY, TEXAS
121	GH	EFFLUENTS AND MAJOR RIVERS, LOUISIANA
122	HJ	MILLERS RIVER, MASSACHUSETTS
123	HJ	MERRIMACK RIVER, MASSACHUSETTS
124	GJ	DELMARVA PENINSULA, DELAWARE/MARYLAND/ VIRGINIA
125	GJ	ROXBORO RESERVOIR, NORTH CAROLINA
126	GK	MARQUETTE/REPUBLIC TRHOUGHS, MICHIGAN
127	GJ	JOHNSON COUNTY GRAVEL TEST, INDIANA
128	GH	MISSISSIPPI DELTA, LOUISIANA
129	FJ	ARKANSAS BASIN
130	EJ	SOUTHERN CALIFORNIA
132	GH	NEW ORLEANS, LOUISIANA
133	GJ	MICHOUD, LOUISIANA
134	GJ	SLIDELL, LOUISIANA
135	DJ	HARVEY VALLEY, CALIFORNIA
136	HJ	NAVY ACRES
137	GJ	MISSISSIPPI TEST FACILITY
138	HJ	GULFSTREAM NORTH
139	EJ	STEAMBOAT SPRINGS, COLORADO
140	EJ	BISHOP, CALIFORNIA
141	GJ	CHARLESTON/COLUMBIA, SOUTH CAROLINA
142	GJ	DELAWARE ESTUARY, PENNSYLVANIA/NEW JERSEY
143	CL	COOK INLET, ALASKA
144	FJ	WISCONSIN SAND PLAINS
145	GH	GULF COAST SPRINGS, FLORIDA
146	GH	ALAFIA AND PEACE RIVERS, FLORIDA
147	GH	LAKES/TAMPA, FLORIDA
148	GJ	LEHIGH RIVER, PENNSYLVANIA
149	FJ	BLACK HILLS, SOUTH DAKOTA
150	GJ	PAMLICO SOUND, NORTH CAROLINA
151	HJ	LONG ISLAND, NEW YORK
152	HJ	BARNEGAT BAY, NEW JERSEY
153	GJ	ANNAPOLIS, MARYLAND
154	EJ	AMBOY CRATER, CALIFORNIA AMBOY CRATER, CALIFORNIA
155	GH	GULF COAST FISHERIES
156	DK	WIND RIVER, WASHINGTON
157	EJ	BORREGO SPRINGS, CALIFORNIA
158	FH	CORPUS CHRISTI, TEXAS/GULF OF MEXICO
159	DJ	HORSEFLY MOUNTAIN, OREGON
160	JK	NEWFOUNDLAND COAST (ARGENTIA)
161	HJ	RARITAN RIVER, NEW JERSEY
162	GH	BAHAMA BANKS, FLORIDA
163	GH	BISCAYNE BAY, FLORIDA

SITE	ZONE	TEST SITE NAME
001	EJ	CEDAR CITY (IRON SPRINGS), UTAH
002	EJ	PISGAH CRATER, CALIFORNIA
003	EJ	MONO CRATERS, CALIFORNIA
004	EJ	CARRIZO PLAIN, CALIFORNIA
005	EJ	EUREKA (TINTIC DISTRICT), UTAH
006	EJ	SALT LAKE (SALT LAKE DISTRICT), UTAH
007	DJ	COAST RANGE, OREGON/WASHINGTON
008	EJ	SOUTH OREGON STRIP, OREGON
009	EJ	SAN FRANCISCO DISTRICT, UTAH
010	EJ	CARSON CITY(COMSTOCK DISTRICT), NEVADA
011	EJ	YELLOWSTONE NATIONAL PARK, WYOMING/ MONTANA/IDAHO
012	DJ	CRATER LAKE, OREGON
013	EJ	SILVER CITY(CENTRAL DISTRICT), NEW MEXICO
014	EJ	LITTLE DRAGOON MOUNTAINS, ARIZONA
015	EJ	TWIN BUTTES (PIMA DISTRICT), ARIZONA
016	FH	SOLITARIO, TEXAS
017	GJ	BALTIMORE (HARFORD-YORK), MARYLAND/ PENNSYLVANIA
018	GJ	HAGERSTOWN (CENTRAL APPALACHIAN) PIEDMONT), MARYLAND/PENNSYLVANIA/VIRGINIA
019	EJ	SONORA PASS, CALIFORNIA
020	DJ	BUCKS LAKE, CALIFORNIA
021	EJ	BATTLE MOUNTAIN (RYE PATCH RESERVOIR/ RUBY MOUNTAINS), NEVADA
022	EJ	TONOPAH, NEVADA
023	DJ	INYO NATIONAL FOREST (WARD MOUNTAIN/ CRATER MOUNTAIN), CALIFORNIA
024	DJ	SAN ANDREAS FAULT, CALIFORNIA
025	EJ	DEVILS PLAYGROUND, CALIFORNIA
026	EJ	SCRIPPS BEACH, CALIFORNIA
027	EJ	SALTON SEA, CALIFORNIA
028	EJ	WINSLOW (METEOR CRATER), ARIZONA
029	EJ	PHOENIX, ARIZONA
030	EJ	TUCSON/AJO, ARIZONA
031	EJ	WILLCOX DRY LAKE, ARIZONA
032	FH	WESLACO, TEXAS
033	FH	GUADELUPE RIVER, TEXAS
034	FJ	OUACHITA MOUNTAINS, ARKANSAS/OKLAHOMA
035	FJ	WICHITA, KANSAS
036	FJ	SPANISH PEAKS, COLORADO
037	EJ	OURAY (SILVERTON/CREEDE DISTRICT AND SAN JUAN 20 QUADRANT), COLORADO
038	EJ	GREAT SAGE PLAIN (LISBON VALLEY), UTAH/ COLORADO
039	EK	EASTERN BEAR TOOTH MOUNTAINS, WYOMING/ MONTANA
040	DK	CASCADE MOUNTAINS (CASCADE GLACIER SITE), WASHINGTON
041	FK	MESABI RANGE, MINNESOTA
042	FK	OTTAWA NATIONAL FOREST (GOGEBIC RANGE), MICHIGAN
043	GJ	CHICAGO, ILLINOIS
044	GJ	PURDUE, INDIANA
045	GJ	ORANGE, VIRGINIA
046	GJ	ASHEVILLE, NORTH CAROLINA
047	GJ	MYRTLE BEACH, SOUTH CAROLINA
048	DJ	SAN PABLO RESERVOIR, CALIFORNIA
049	DJ	DAVIS, CALIFORNIA
050	DJ	DONNER PASS, CALIFORNIA
051	EJ	MESQUITE SEDIMENTARY, ARIZONA
052	EJ	NEVADA AEC
053	EJ	SPANISH PEAKS, COLORADO/CEDAR CITY, UTAH
054	EJ	SMOKE CREEK DESERT/HEBER, UTAH
055	EJ	HUMBOLDT BASIN, NEVADA
056	DJ	MT.LASSEN, CALIFORNIA
057	BH	HAWAII
058	EJ	VALLES CALDERA, NEW MEXICO
059	EJ	TOBIN RANGE, NEVADA
060	EJ	DIXIE VALLEY, NEVADA
061	DJ	THE GEYSERS, CALIFORNIA
062	DJ	MT. SHASTA, CALIFORNIA
063	DJ	NEWBERRY CRATERS, OREGON
064	DJ	CENTRAL CASCADE RANGE, OREGON
065	DK	MT. HOOD, OREGON
066	DK	MT. ADAMS, WASHINGTON
067	DK	MT. ST. HELENS, WASHINGTON
068	DK	MT. RAINIER, WASHINGTON
069	DK	MT. BAKER, WASHINGTON
070	HJ	HOPKINTON-MILFORD/TEMPLETON/ORANGE, MASSACHUSETTS
071	EJ	HOPI BUTTES, ARIZONA
072	EJ	COSO HOT SPRINGS, CALIFORNIA
073	EJ	LYNN DISTRICT, NEVADA
074	EJ	BENTON, CALIFORNIA
075	EJ	GOLDFIELD, NEVADA
076	FJ	GARDEN CITY, KANSAS
077	GJ	NORFOLK, VIRGINIA
078	GJ	CLEVELAND COUNTY, NORTH CAROLINA
079	GJ	MATEWAN, KENTUCKY
080	EJ	BIG PINE FAULT, CALIFORNIA

SITE	ZONE	TEST SITE NAME
081	EJ	MT. MORRISON FAULT, CALIFORNIA
082	EJ	ALVORD VALLEY, OREGON
083	FJ	IRONTON, MISSOURI
084	EJ	ALAMOSA, COLORADO
085	FJ	LAWRENCE, KANSAS
086	HJ	ARGUS ISLE, BERMUDA
087	JK	GOOSE BAY, LABRADOR
088	FJ	MISSISSIPPI VALLEY, MISSOURI/TENNESSEE
089	EK	BLACKBIRD DISTRICT, IDAHO
090	EK	ALBERTON, MONTANA
091	EK	TOBACCO ROOT MOUNTAIN, MONTANA
092	HH	PUERTO RICO
093	BL	PT. BARROW, ALASKA
094	GJ	NORTHEAST PENNSYLVANIA (PEAT BOGS)
095	GH	EVERGLADES, FLORIDA
096	EJ	DIXIE/FISH LAKE NATIONAL FOREST, UTAH
097	HJ	CAPE COD/MARTHA'S VINEYARD, MASSACHUSETTS
098	GH	HOMESTEAD, FLORIDA
099	GH	FLORIDA STRAITS
100	FJ	HOT SPRINGS, ARKANSAS
101	EJ	SAN FRANCISCO VOLCANIC FIELDS, ARIZONA
102	GJ	STATENVILLE, GEORGIA/LAKE CITY, FLORIDA, PHOSPHATE
103	GH	CRYSTAL RIVER, FLORIDA
104	GH	WAUCHULA/TAMPA, FLORIDA
105	GH	CRESCENT BEACH SUBMARINE SPRING, FLORIDA
106	GH	CLEARWATER/NAPLES SUBMARINE SPRING, FLORIDA
107	GH	CAPE SABLE SUBMARINE SPRING, FLORIDA
108	GH	CUTLER AREA SUBMARINE SPRING, FLORIDA
109	FJ	SIERRA MADERA, TEXAS
110	EK	CLARK FORK, IDAHO
111	EJ	WET MOUNTAIN, COLORADO
112	EJ	NORTHEAST RANGE, COLORADO
113	GJ	FAYETTEVILLE, NORTH CAROLINA/NEWPORT, TENNESSEE
114	EJ	WHITE SANDS, NEW MEXICO
115	EJ	NEW MEXICO MINERAL AND STRUCTURAL BELTS
116	EJ	GREAT SALT LAKE, UTAH
117	EJ	LAKE CACHUMA, CALIFORNIA
118	FK	MISSOURI RIVER, NORTH DAKOTA
119	FJ	BUTLER COUNTY, KANSAS
120	FJ	LAKE COLORADO CITY, TEXAS
121	GH	EFFLUENTS AND MAJOR RIVERS, LOUISIANA
122	HJ	MILLERS RIVER, MASSACHUSETTS
123	HJ	MERRIMACK RIVER, MASSACHUSETTS
124	GJ	DELMARVA PENINSULA, DELAWARE/MARYLAND/ VIRGINIA
125	GJ	ROXBORO RESERVOIR, NORTH CAROLINA
126	GK	MARQUETTE/REPUBLIC TRHOUGHS, MICHIGAN
127	GJ	JOHNSON COUNTY GRAVEL TEST, INDIANA
128	GH	MISSISSIPPI DELTA, LOUISIANA
129	FJ	ARKANSAS BASIN
130	EJ	SOUTHERN CALIFORNIA
132	GH	NEW ORLEANS, LOUISIANA
133	GJ	MICHOUD, LOUISIANA
134	GJ	SLIDELL, LOUISIANA
135	DJ	HARVEY VALLEY, CALIFORNIA
136	HJ	NAVY ACRES
137	GJ	MISSISSIPPI TEST FACILITY
138	HJ	GULFSTREAM NORTH
139	EJ	STEAMBOAT SPRINGS, COLORADO
140	EJ	BISHOP, CALIFORNIA
141	GJ	CHARLESTON/COLUMBIA, SOUTH CAROLINA
142	GJ	DELAWARE ESTUARY, PENNSYLVANIA/NEW JERSEY
143	CL	COOK INLET, ALASKA
144	FJ	WISCONSIN SAND PLAINS
145	GH	GULF COAST SPRINGS, FLORIDA
146	GH	ALAFIA AND PEACE RIVERS, FLORIDA
147	GH	LAKES/TAMPA, FLORIDA
148	GJ	LEHIGH RIVER, PENNSYLVANIA
149	FJ	BLACK HILLS, SOUTH DAKOTA
150	GJ	PAMLICO SOUND, NORTH CAROLINA
151	HJ	LONG ISLAND, NEW YORK
152	HJ	BARNEGAT BAY, NEW JERSEY
153	GJ	ANNAPOLIS, MARYLAND
154	EJ	AMBOY CRATER, CALIFORNIA
		AMBOY CRATER, CALIFORNIA
155	GH	GULF COAST FISHERIES
156	DK	WIND RIVER, WASHINGTON
157	EJ	BORREGO SPRINGS, CALIFORNIA
158	FH	CORPUS CHRISTI, TEXAS/GULF OF MEXICO
159	DJ	HORSEFLY MOUNTAIN, OREGON
160	JK	NEWFOUNDLAND COAST (ARGENTIA)
161	HJ	RARITAN RIVER, NEW JERSEY
162	GH	BAHAMA BANKS, FLORIDA
163	GH	BISCAYNE BAY, FLORIDA

SITE	ZONE	TEST SITE NAME
164	GH	BOCA RATON/BELLE GLADE, FLORIDA
165	GJ	DESERET/ST. MARKS, FLORIDA
166	LL	ICELAND, NORTH ATLANTIC
167	GJ	LAKE MICHIGAN
168	GJ	PATUXENT RIVER, MARYLAND
169	GH	FLORIDA KEYS
170	EJ	SHEEP MOUNTAIN, WYOMING
171	FH	SABINE LAKE ESTUARY, TEXAS/LOUISIANA
172	GH	YUCATAN PENINSULA, MEXICO
173	GH	GULF LOOP
174	GJ	WALLOPS ISLAND VIRGINIA
175	FH	HOUSTON, TEXAS, AREA
176	HJ	NEW ENGLAND
177	GJ	TENNESSEE VALLEY
178	FJ	MILL CREEK, OKLAHOMA
179	FH	LAGUNA MADRE AND CORPUS CHRISTI, TEXAS
180	EJ	GARNET MOUNTAIN, ARIZONA
181	EJ	COLORADO RIVER DELTA, MEXICO
182	GH	WEST PALM BEACH, FLORIDA
183	EJ	LORDSBURG, NEW MEXICO
184	FJ	CHICKASHA, OKLAHOMA
185	EJ	BONANZA AREA, COLORADO
186	EJ	CLARK FORK, WYOMING
187	HJ	BOSTON, MASSACHUSETTS
188	HJ	NEW YORK BIGHT
189	DJ	KLAMATH FALLS, OREGON
190	GJ	ANN ARBOR, MICHIGAN
191	GJ	WASHTENAW COUNTY, MICHIGAN
192	JG	BARBADOS
193	DJ	EL DORADO FOREST, CALIFORNIA
194	FJ	DENVER, COLORADO
195	FJ	BROOKINGS, SOUTH DAKOTA
196	GK	GRAND SABLE, MICHIGAN
197	FK	CHIPPEWA NATIONAL FOREST, MINNESOTA
198	GJ	MISSISSIPPI SOUND
199	FH	GALVESTON ISLAND, TEXAS
200	FJ	KERR COUNTY, TEXAS
201	GJ	MECHANICSBURG, PENNSYLVANIA
202	FH	PT. COMFORT, TEXAS
203	FJ	GRANITE CITY, ILLINOIS
204	GJ	BYNUM, ALABAMA
205	FJ	BATON ROUGE, LOUISIANA
206	GJ	MUSCLE SHOALS, ALABAMA
207	EK	MOSES LAKE, WASHINGTON
208	GJ	BARABOO, WISCONSIN
209	EJ	FORT APACHE/SAN CARLOS INDIAN RESERVATION, ARIZONA
210	EJ	IMPERIAL VALLEY, CALIFORNIA
211	DJ	SAN FRANCISCO BAY AREA, CALIFORNIA
212	FJ	MARATHON, TEXAS
213	FJ	COLORADO RIVER, TEXAS
214	EH	GULF OF CALIFORNIA
215	HJ	LONG ISLAND SOUND, NEW YORK
216	FK	JAMESTOWN, NORTH DAKOTA
217	GJ	ATLANTA, GEORGIA
218	FJ	SIOUX FALLS, SOUTH DAKOTA
219	CL	BEAUFORT SEA, ALASKA
220	EJ	FORT HUACHUCA, ARIZONA
221	BK	KATMAI NATIONAL MONUMENT, ALASKA
222	FH	BIG BEND NATIONAL PARK, TEXAS
223	FJ	VAN HORN, TEXAS
224	GJ	JAMES RIVER, VIRGINIA
225	EJ	RIVERSIDE, CALIFORNIA
226	GJ	PEORIA, ILLINOIS
227	FJ	WITCHITA FALLS, TEXAS
228	FJ	MIDLAND, TEXAS
229	HJ	NEW HAVEN, CONNECTICUT
230	GJ	WASHINGTON, D.C.
231	GJ	PONTIAC, MICHIGAN
232	GJ	AURORA, ILLINOIS
233	GH	TAMPA, FLORIDA
234	FJ	CEDAR RAPIDS, IOWA
235	EJ	SALT LAKE CITY, UTAH
236	DK	SEATTLE, WASHINGTON
237	HH	VIRGIN ISLANDS
238	FJ	LUBBOCK, TEXAS
239	GJ	LAKE ONTARIO, U.S./CANADA
240	HK	CATHEART MOUNTAIN, MAINE
241	FH	EAGLE PASS, TEXAS
242	FJ	MANITOU, COLORADO
243	EJ	STANISLAUS NATIONAL FOREST, CALIFORNIA
244	GJ	CENTRAL ATLANTIC COASTAL AREA
245	EJ	MARBLE, COLORADO
246	EJ	GILA RIVER, ARIZONA
247	GH	AUTEC/ANDROS ISLAND, BAHAMAS
248	GJ	NORTH CAROLINA COAST
249	GJ	GUYANDOTTE RIVER, WEST VIRGINIA
250	GJ	INDIANA GRAIN BELT
251	GJ	DESTIN, FLORIDA
252	GJ	CHESAPEAKE BAY, MARYLAND/VIRGINIA
253	FH	CENTRAL GULF COASTAL AREA
254	DJ	CALIFORNIA COASTAL AREA
255	FJ	NORTH HIGH PLAINS, SOUTH DAKOTA
256	FH	TRINITY BAY, TEXAS
257	FJ	TRINITY RIVER, TEXAS
258	GJ	PITTSBURG, PENNSYLVANIA
259	EJ	ARETS (ARIZONA REGIONAL ECOLOGICAL TEST SITE)
260	EJ	CALIFORNIA (FEATHER RIVER PROJECT)
261	EJ	JORNADA BIOME, NEW MEXICO
262	FJ	ENCHANTED ROCK, TEXAS
263	FJ	GUADALUPE MTS, TEX/N.M.
264	EJ	PAINTED DESERT/PETRIFIED FOREST, ARIZONA
265	GH	GULF OF MEXICO
701	FH	EL ORO/TLALPUJAHUA, MEXICO
702	FH	IXTLAN DE LOS HERVORES/LOS NEGRITOS, MEXICO
703	FH	TOLUCA IXTLAHUACA, MEXICO
704	FH	CHAPINGO, MEXICO
705	FH	VERACRUZ, MEXICO
706	FH	PAPALOAPAN BASIN, MEXICO
707	FH	CUATROCIENEGAS, MEXICO
708	FH	SAN JOSE DE LAS RUSIAS, MEXICO
710	JH	BOMEX
801	JE	CAMPINAS, BRAZIL
802	KE	IPEACS (KM-47), BRAZIL
803	KE	QUADRILATERO FERRIFERO, BRAZIL
804	KE	RIO DE JANEIRO, BRAZIL
805	KE	CABO FRIO, BRAZIL
851	GF	PERU (EARTHQUAKE)
901	HE	GREAT CHACO REGION, ARGENTINA
992	FH	FIREANT, (TEXAS)
993	GH	TITUSVILLE, FLORIDA
994	EJ	EL PASO, TEXAS
995	FJ	ANSON/SNYDER, TEXAS
996	FJ	DALLAS/FT. WORTH, TEXAS
997	GH	CAPE KENNEDY, FLORIDA

Appendix C
LIST OF ORGANIZATIONAL ADDRESSES

Air Force Cambridge Research Laboratories
Laurence G. Hanscom Field
Bedford, Massachusetts 01730

American Electric Power Service Corporation
Two Broadway
New York, New York 10004

Argonne National Laboratory
9700 South Cass
Argonne, Illinois 60439

Bureau of Reclamation
Denver Federal Center
Denver, Colorado 80225

U. S. Army Corps of Engineers
Detroit, Michigan 48222

East Tennessee State University
State University Substation
Johnson City, Tennessee 37601

Environmental Research Institute of Michigan
P. O. Box 618
Ann Arbor, Michigan 48107

Federal Highway Administration
United States Department of Transportation
Washington, D. C. 20591

Highway Research Council
Box 3817, University Station
Charlottesville, Virginia 22903

Michigan State University
East Lansing, Michigan 48823

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

National Aeronautics and Space Administration
John F. Kennedy Space Center
Kennedy Space Center, Florida 32899

National Aeronautics and Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

National Aeronautics and Space Administration
Wallops Flight Center
Wallops Island, Virginia 23337

National Park Service
West Regional Office
450 Golden Gate Avenue
P. O. Box 36063
San Francisco, California 94102

North American Rockwell
12214 Lakewood Boulevard
Downey, California 90241

NOAA/NESS
3737 Branch Avenue
Washington, D. C. 20031

Oregon State University
Department of Oceanography
Corvallis, Oregon 97331

Purdue University
Laboratory for Applications of Remote Sensing
Purdue Industrial Research Park
1220 Potter Drive
West Lafayette, Indiana 47906

South Dakota State University
Brookings, South Dakota 57006

State Highway Administration
Bureau of Public Roads
1717 H Street
Washington, D. C. 20591

Tennessee Valley Authority
Norris, Tennessee 37828

United States Department of Agriculture
Forestry Service
Pacific Southwest Forest and Range Experiment Station
1960 Addison Street, P. O. Box 245
Berkeley, California 94701

United States Department of Agriculture
Forestry Service
Rocky Mountain Forest and Range Experiment Station
240 West Prospect Street
Fort Collins, Colorado 80521

United States Department of Agriculture
Agricultural Research Service
P. O. Box 267
Weslaco, Texas 78596

United States Department of the Interior
Fish and Wildlife Service
Northern Prairie Wildlife Research Center
Jamestown, North Dakota 58401

United States Energy Research and Development Administration
Morgantown Energy Research Center
P. O. Box 880
Collins Ferry Road
Morgantown, West Virginia 26505

United States Department of the Interior
Geological Survey
Denver Federal Center
Denver, Colorado 80225

United States Geological Survey
Water Resources Division
901 South Miami Avenue
Miami, Florida 33130

United States Geological Survey
Department of the Interior
Water Resources Division
500 Zack Street
Tampa, Florida 33602

United States Geological Survey
2221 Jefferson Davis Highway
Arlington, Virginia 22202

United States Geological Survey
GSA Building, Room G-204
Washington, D. C. 20242

University of California
School of Forestry
Berkeley, California 94720

University of California, Riverside
Riverside, California 92502

University of Kansas
Space Technology Center
Irving Hill Drive
Lawrence, Kansas 66044

University of Michigan
Ann Arbor, Michigan 48104

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